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[OFFICIAL NOTICE.]

Third Annual Meeting, Texas Gas and Electric Light Association.

OFFICE OF THE SECRETARY,
GONZALES, TEX., March 11, 1897.

The third annual meeting of the Texas Gas and Electric Light Association will be held in the Menger Hotel, San Antonio, Tex., on Monday, Tuesday and Wednesday, the 19th, 20th and 21st days of April, 1897. The following papers will be read:

"The Commercial Efficiency of the Incandescent Electric Light," by Mr. H. L. Monroe, Dallas, Tex.

"A Means of Largely Increasing the Summer Sendout of a Gas Works," by Mr. J. C. Lord, Fort Worth, Tex.

"The Storage Battery as an Adjunct to Small Electric Light Plants," by Mr. W. L. Hall, Mexia, Tex.

"A Few of the Many Details of Management," by Mr. A. E. Judge, Tyler, Tex.

"Little Things," by Mr. W. E. Holmes, Austin, Tex.

"Operating Expenses of Electric Light Plants," by Mr. J. D. Oliger, Cleburne, Tex.

"Electrolytic Deterioration of Water and Gas Mains," by Mr. W. A. Fraser, Dallas, Tex.

A few other short papers may be read. The Question Box will be a special feature of the meeting, and it is hoped the Wrinkle Department will also prove interesting.

It is expected, and an effort is being made, to have an exhibit of gas and electrical appliances, which it is believed will be both interesting and instructive.

The last day of the meeting is "San Jacinto Day," a great holiday in Texas, and in San Antonio especially, when the "Battle of the Flowers" takes place.

Effort is being made to obtain cheap railroad rates, and everything will be done to make the expense of attending as light as possible.

The Secretary will take pleasure in sending blank applications for membership and information regarding the Association to those interested.

F. R. STARR, JR., Secretary.

BRIEFLY TOLD.

THE COZE PATENTS SUSTAINED.—An action for infringement of patent rights that attracted great attention in European gas circles was decided something over a fortnight ago, the opinion having been rendered by Mr. Justice Romer, sitting in the Chancery Division of the High Court of Justice, England. The case was entitled the "Automatic Coal Gas Retort Company, Limited, versus The Corporation of Salford," and its subject was the contention by plaintiff that defendant, at its municipally operated gas plant in Salford, had used without license or permission inclined retorts for generating coal gas, the principle of which construction was vested in plaintiff. An injunction was asked for, also damages, etc. Quite an array of able counsel appeared in the case, and the testimony given by experts, for and against the matter in hand, was exceedingly interesting. Defendants admitted

practically that the principle of the Coze system was at the base of their construction and use of the inclined retorts at Salford, but pleaded in defense that improvements of their own devising had so altered the Coze plan mechanically as to virtually cause the Salford practice to take on the merit of originality. Plaintiffs contended that the wording of their patents was such as to give them protection for retorts set in sloping position, such retorts to be used for the production of gas, and that the changes made in the Coze plan, as the slopers were installed at Salford, were only matters of alteration in mechanical detail, and in no sense of principle. Having carefully weighed the testimony, Justice Romer delivered a highly interesting decision, in which he upheld the plaintiffs' case, at one point in it remarking: "Speaking for myself, I think if you once look at the defendants' apparatus and see how it works, the thing is at end. They have made, I admit, improvements in the details of carrying out the patentee's invention—I think it might be said very useful modifications and improvements—but when the apparatus of the defendants is looked at it appears impossible to say that they have not adopted the plaintiffs' system. In my opinion they have. The defendants' apparatus is nothing more than the plaintiffs' system with modifications." In due time we shall publish, through our English correspondent, Mr. Humphrys, a *résumé* of the case and the decision. It is likely that the case will be appealed to the Appeal Court.

Death of Mr. S. E. Bird.—Mr. Sharpless E. Bird, President of the Mansfield (O.) Gas Light Company, died at his home in that city on the evening of March 29th. His death was the sequel to an illness (a lung affection was the ailment from which he suffered) that extended over a period of 15 years, but during all that time his perseverance and pluck were of a quality that enabled him to successfully battle with business cares almost to the end. He was born in Catawissa, Pa., December 20, 1844, and removed with his parents, in 1867, to Mansfield, where he engaged with his father in the hardware business. In this line of trade he continued, under different partnerships, up to a year ago. Meanwhile he had engaged in the hotel business, and at the time of his death he was proprietor of the Hotel Vonhof. His interest in the Mansfield Gas Light Company was maintained for many years, and he was an active member of the Ohio Gas Light Association. He was united in marriage, July 4, 1869, to Miss Lizzie Vonhof, who, with two daughters, survives him. He was prominent in Masonic circles, and was also well known in the social life of Mansfield. The funeral services were held in the First Presbyterian Church, Mansfield, on the afternoon of April 1st, the Reverend Dr. Meese officiating. The services at the grave were directed according to the ritual of the Knights Templar. Deceased was very much esteemed by his associates, and no other man held a higher place in the respect of the community where the greater part of his useful life was spent.

"Uncle Jerry" Howard Has a Birthday.—Not that that has been an unusual occurrence in the life's history of the genial, sunshiny man, for this particular "birthday" was the 67th anniversary thereof. March 16th was the day, and early that evening it was when the wholesouled President and Manager of the Galena Gas Company was confronted in his home by 19 prominent residents of Galena, headed by Judge W. T. Hodson, who, acting as spokesman for the party, told "Uncle Jerry" just what they thought of him. The Judge finished his speech by pointing to and formally presenting Mr. Howard with a handsome extension chair. Mr. Howard naturally was "stumped" for a moment by the circumstances, but only for a moment. Recovering his mental poise he easily matched the witty and loyal words spoken by the Judge, although there was a suspicious faltering of his voice when he told his hearers how much he appreciated their estimate of himself. A right pleasant home entertainment followed the presentation.

Notes.—The Kansas City-Missouri Gas Company is an accomplished fact. The President of the Company is Colonel M. J. Payne, formerly President of the Kansas City Gas Company; the capital stock has been put at $5,000,000, and the gas rate has been put at the figure of $1 per 1,000, the rate to go into effect May 1st. It is likely that the manufacturing plant of the Missouri Gas Company will be shut down, although the holder will be utilized. The executive offices of the Missouri Company will also be closed.——Work has been commenced on the new 1,000,000-foot holder for the Grand Rapids (Mich.) Gas Company.——Mica chimneys can be readily and safely cleansed by immersing them in a bath of *ice water*.——The Milwaukee Gas Light Company has arranged for an award of money prizes in gold for the best reasons (10 in number) proving that gas should be used in the kitchen to the exclusion of solid fuels.

The Flow of Gas or Steam Through Pipes.

A Comprehensive Table of the Flow of Gas or Steam through Pipes, with an Examination of Some of the Formulæ now in Use.

[By Mr. Arthur J. Martin, in *Engineering*.]

The flow of gases through pipes has not been investigated so fully as in the case of water, and the tables which we have for gases are neither very reliable nor convenient in use.

In preparing a table for gases, we are met at the outset by a difficulty which does not exist with water, viz., the variation which takes place in the density of a gas with every change in its pressure or temperature.

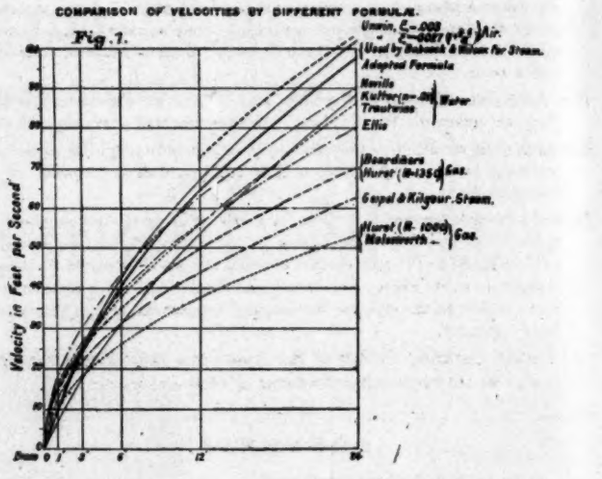
In considering the flow of a gas through a pipe, we have five variable quantities to take into account, viz., the volume passing, the density or weight per cubic foot, the diameter of the pipe, its length, and the "head" or loss of pressure which takes place in the pipe. If, instead of taking the length and loss of pressure separately, we use the ratio which the latter bears to the former, these five variables will be reduced to four.

In an ordinary table or diagram three variables only can be expressed. Hence we have tables for a given density, for a given diameter, or for a given loss of pressure in a given length, which are practically useless if the density, diameter, or loss of pressure is different from that on which the table is based. It is obvious that separate tables for all the changing conditions with which we have to deal would be too many to be conveniently used.

In the three tables here given, a device has been adopted, whereby they are made to cover all the conditions which occur in ordinary practice.

The first step in the preparation of these tables was the selection of a formula.

Fig. 7.



The experimental data on which a formula can be based are scanty; and the results which have been arrived at by different observers somewhat conflicting.

A general formula for the flow of fluid (whether liquid or gaseous) through a pipe, has been given by Professor Unwin, as follows:

$$H = \varsigma \cdot \frac{v^2}{2g} \cdot \frac{4L}{D},$$

where H = head in feet of fluid; v = velocity in feet per second; g = acceleration due to gravity, taken as 32.2; L = length of pipe, and D = its diameter, both in feet. ς is a coefficient for friction, which Prof. Unwin stated in 1880 as

$$.0027\left(1 + \frac{3}{10\,D}\right);$$

and, subsequently, as the result of Professor Riedler's experiments in the compressed air mains of Paris, as .003 for diameters not less than 1 foot.

Mr. Hawksley's general formula for water and gases is

$$v = 48\sqrt{\frac{H\,D}{L}},$$

the symbols being the same as above. Mr. J. T. Hurst gives for coal gas

$$Q = M\sqrt{\frac{D^5 p}{G\,L}},$$

Q being quantity in cubic feet per hour, M a constant, given as 1,000, or 1,350 under very favorable circumstances, L length of pipe in yards, D diameter in inches, p water pressure in inches, and G specific gravity of gas, that of air being unity. The same formula is given by Mr. Molesworth, who adopts 1,000 as the value of M. The Chapman Valve Manufacturing Company, in the engineering appendix to their catalogue, give the same formula, but with M = 1,350.

Mr. Beardmore gives a table of constants for different diameters, which, being divided by the square root of the product of the specific gravity of the gas, as compared with air, multiplied by the rate of inclination (length divided by head) give the discharge in cubic feet per minute. I have worked out from this table the formula

$$p = \frac{w^2 L}{3{,}192\, D\, d^5},$$

the symbols being those given below, which will be used throughout the remainder of this paper:

L = length of pipe in feet;
d = diameter of pipe in inches;
D = density of fluid in pounds per cubic foot;
p = loss of pressure in pounds per square inch;
w = delivery of fluid in pounds per minute.

Messrs. Babcock & Wilcox, in their publication, *Steam*, give a formula

$$w = 87\sqrt{\frac{D\, p\, d^5}{L\left(1 + \frac{3.6}{d}\right)}}$$

which is practically identical with Prof. Unwin's original formula, though in another form.

In an article in the *Electrician* of May 5, 1893, Messrs. Geipel and Kilgour give two diagrams for the flow of steam, which by calculation yield the formula

$$p = \frac{w^2 L}{2{,}525\, D\, d^5}.$$

Mr. D. K. Clark quotes a table given by Mr. Cornut for compressed air, which is unfortunately rendered useless by the omission to state the absolute pressure or the density for which it is calculated.

The formulæ of different authors are given in so many different forms that it is difficult to compare them as they stand. In order to do so more readily, I have applied them to two cases under widely differing conditions, and give here the loss of pressure obtained by each formula. In case I. 17.16 cubic feet per minute (= 1.088 lb.) of gas having a density of .0634 lb. per cubic foot (giving a specific gravity of .833), are passing at ordinary atmospheric pressure through 3,280 ft. of 4-in. pipe. In case II. 927.4 cubic feet per minute of the same gas at a pressure of 50 atmospheres (giving a density of 3.1734 lb. per cubic foot, and a weight of 2,943 lb. per minute), are passed through 3,280 ft. of 12-in. pipe.

	Loss of Pressure in Pounds per Square Inch.	
	Case I.	Case II.
Prof. Unwin's original formula	.0148	6.10
Mr. Hawksley	.0202	12.15
Mr. Hurst (M = 1,350)	.0187	11.27
Mr. Beardmore	.0187	11.27
Messrs. Babcock and Wilcox	.0150	6.19
Messrs. Geipel and Kilgour	.0237	14.25
Mr. Cornut (D. K. Clark)	(?).114	(?) 1.482
Formula herein proposed	.0162	6.68

While Mr. Hawksley's, Mr. Hurst's and Mr. Beardmore's formulæ give approximately the same results, the loss of pressure in each case being much greater than is called for by Professor Unwin's, yet the latter is supported by the average result of experiments made on a very large scale in the compressed air mains of Paris, which entitle it to careful attention.

This formula differs from all the others in giving velocities proportional to the square root of

$$\left\{ \text{the diameter} \div \left(1 + \frac{3.6}{d}\right) \right\}$$

(expressed in inches instead of feet as in the original), while most of the other formulæ given above agree in making the velocity directly proportional to the square root of the diameter.

Fig. 2.

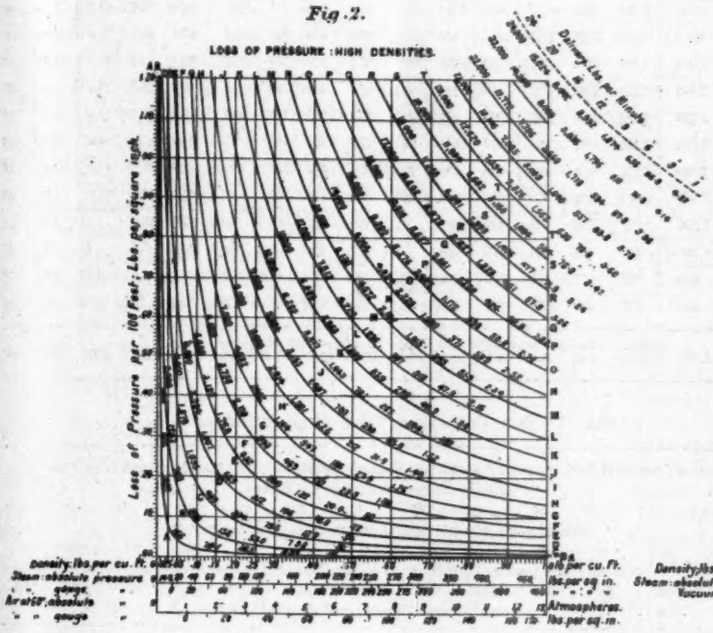
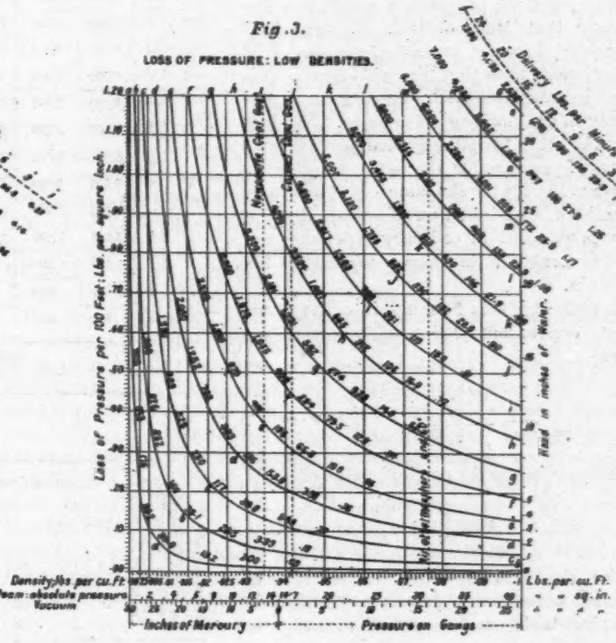


Fig. 3.


LOSS OF PRESSURE: LOW DENSITIES.
Loss of Pressure per 100 Feet: Lbs. per square inch.
Delivery Lbs per Minute
Rise in inches of Water.
Density: lbs per cu. Ft.
Steam: absolute pressure
Vacuum
Lbs. per cu. Ft.
sq. in.
Inches of Mercury
Pressure on Gauge

In hydraulic formulæ, however, it is only the older formulæ which give the velocity proportional to the square root of the diameter, the newer formulæ giving an increasing ratio. There is no conceivable reason why the general rule which has been established in the case of the one fluid, from which most of the existing data have been obtained, should not hold good with all; although it is possible that the constants obtained with water may not be exactly the same as for gases.

For the sake of showing how the velocity increases with the diameter, according to different formulæ, the following table of proportional velocities has been prepared, the chief results being shown also in diagram Fig. 1. The density of the gas is assumed as 1, and the head as 1 in 1, or .694 lb. per 100 feet. The velocity for a 1-in. pipe in each case being taken as unity, the proportional velocities for other diameters will be as follows:

	Diameter. 6 in.	12 in.	24 in.
Messrs. Hawksley's, Hurst's, Molesworth's, Beardmore's, Geipel and Kilgour's, and all other formulæ in which v varies as $\sqrt{d}$	2.45	3.46	4.90
Mr. G. A. Ellis	2.53	3.61	5.17
Mr. Neville	2.56	3.67	5.25
Mr. Trautwine	2.66	3.92	5.97
Prof Unwin, Messrs. Babcock & Wilcox, and formula herein proposed	4.15	6.52	9.81
Messrs. Ganguillett and Kutter	4.45	7.54	12.40

It will be seen by Diagram No. I. that Professor Unwin's results correspond fairly well with those given by the hydraulic formulæ, as well, indeed, as the latter agree among themselves, giving, on the whole, somewhat higher velocities than they do. It, therefore, seems advisable to adopt his rule for the proportional discharging power of different diameters rather than the ratio of the square roots.

It remains to be decided what constant shall be adopted. Professor Unwin's formula gives velocities higher, not only than those given by any of the other formulæ under consideration, either for gas or for water, but higher also than many of those obtained from Professor Riedler's Paris experiments.

Professor Unwin's later value of ς (the coefficient of friction) is .003 for pipes not under 12 in. in diameter. The average value obtained from the experiments is .0029, the individual results ranging from .00181 up to .00449, the highest figure being more than 50 per cent. above the average.

For practical purposes it seems less important that the constant adopted shall represent the exact average of a given set of experiments than that the results given by it shall be attainable with some degree of certainty in ordinarily good practice. The fact that the other formulæ quoted give greater losses of pressure for the same velocity, or lower velocities for the same loss of pressure, than Prof. Unwin's, would indicate that the results obtained in ordinary experience are less favorable than those assigned by his formula.

Translating this formula into the form most convenient for ordinary use, we have

$$p = \frac{w^2 L\left(1 + \frac{3.6}{d}\right)}{7{,}665\ D\ a^2}$$

corresponding to the original value of

$$\varsigma = .0027\left(1 + \frac{3.6}{d}\right)$$

For the reasons above stated, it was thought advisable in preparing the accompanying tables and diagrams to assign a somewhat lower value to the constant in the divisor, which has therefore been placed at 7,000 instead of 7,665. This gives a value to ς corresponding with the average of the four highest values obtained from Professor Riedler's thirteen experiments; and gives results which should be attainable in good practice.

For convenience in arriving at any factor connected with discharge, the remaining factors being known, the following formulæ are given, all being derived from

$$p = \frac{w^2 L\left(1 + \frac{3.6}{d}\right)}{7{,}000\ D\ a^2}$$

The formula for diameter is approximate only, the full formula being too complex for ordinary use. It is correct for a diameter of 9 inches, the results being slightly too high with larger diameters and too low with smaller diameters. The formula is, however, useful for obtaining trial diameters for use in further calculations.

TABLE I.—Flow of Gases in Pipes.

Proportional Discharges for Different Diameters (Weight in Pounds per Minute), Density of Gas and Loss of Pressure in a given Length remaining the same throughout each Line of Table.

Reference Letter. High.	Low.	Diameter of Pipe in Inches. 24 in.	22 in.	20 in.	18 in.	16 in.	14 in.	12 in.	10 in.	9 in.	8 in.	7 in.	6 in.	5 in.	4 in.	3 in.	2 in.	1 in.
T	..	20,000	15,904	12,520	9540	7034	4972	3328	2062	1562	1142	802	530	324	176.4	79.8	25.8	3.60
S	..	19,000	15,194	11,894	9063	6682	4723	3160	1959	1484	1085	762	504	308	168	75.8	24 5	3.42
R	..	18,000	14,396	11,268	8586	6331	4475	2993	1856	1406	1028	722	477	292	159	71.8	23.2	3 24
Q	..	17,000	13,593	10,642	8109	5979	4226	2827	1753	1328	971	682	451	276	150	67.8	21.9	3 06
P	..	16,000	12,795	10,016	7632	5627	3978	2661	1650	1250	914	642	424	259	141	63.8	20.6	2.88
O	..	15,000	11,995	9,390	7155	5276	3729	2495	1547	1172	857	602	398	243	132	59.8	19.3	2.70
N	..	14,000	11,196	8,764	6678	4924	3480	2328	1443	1093	799	561	371	227	123	55.9	18.1	2.52
M	..	13,000	10,396	8,138	6201	4572	3231	2162	1340	1015	742	521	345	211	114	51.9	16.8	2.34
L	..	12,000	9,596	7,512	5724	4220	2983	1996	1237	937	685	481	318	194	106	47.9	15.5	2.16
K	..	11,000	8,796	6,886	5247	3868	2736	1830	1134	859	628	441	292	178	97.0	43.9	14.2	1.98
J	i	10,000	7,997	6,260	4770	3517	2486	1663	1031	781	571	401	265	162	88.2	39.9	12.9	1.80
	h	9,500	7,597	5,947	4532	3341	2362	1580	979	742	542	381	252	154	83.8	37.9	12.3	1.71
I	g	9,000	7,197	5,634	4293	3165	2237	1497	928	703	514	361	239	146	79.4	35.9	11.6	1.62
	f	8,500	6,797	5,321	4054	2989	2113	1414	876	664	485	341	226	138	75.0	33.9	10.9	1.53
H	e	8,000	6,398	5,008	3816	2814	1989	1331	825	625	457	321	212	130	70.6	31.9	10.3	1.44
	d	7,500	5,998	4,695	3577	2638	1865	1248	773	586	428	301	199	122	66.2	29.9	9 68	1.35
G	c	7,000	5,598	4,382	3339	2462	1740	1164	722	547	400	281	186	113	61.7	27.9	9.03	1.26
	b	6,500	5,198	4,069	3100	2286	1616	1081	670	508	371	261	172	105	57.3	25.9	8.38	1.17
F	a	6,000	4,799	3,756	2862	2110	1492	998	619	469	343	241	159	97.2	52.9	23.9	7.74	1.08
	k	5,500	4,398	3,443	2623	1934	1368	915	567	430	314	221	146	89.1	48.5	21.9	7.10	.99
E	j	5,000	3,998	3,130	2385	1758	1243	832	516	390	286	200	132	81.0	44.1	20.0	6.45	.90
	i	4,500	3,599	2,817	2147	1583	1119	748	464	351	257	180	119	72.9	39.7	18.0	5.81	.81
D	h	4,000	3,199	2,504	1908	1407	994	665	412	312	228	160	106	64.8	35.3	16.0	5.16	.72
	g	3,500	2,799	2,191	1670	1231	870	582	361	274	200	140	92.8	56.7	30.9	14.0	4.52	.63
C	f	3,000	2,399	1,878	1431	1055	746	499	309	234	171	120	79.5	48.6	26.5	12.0	3.87	.54
	e	2,500	1,999	1,565	1193	879	622	416	258	195	143	100	66.3	40.5	22.1	10.0	3.23	.45
B	d	2,000	1,599	1,252	954	703	497	333	206	156	114	80.2	53.0	32.4	17.6	7.98	2.58	.36
	c	1,500	1,200	939	716	528	373	250	155	117	85.7	60.2	39.8	24.3	13.2	5.98	1.93	.27
A	b	1,000	800	626	477	352	249	166	103	78.1	57.1	40.1	26.5	16.2	8.82	3.99	1.29	.18
	a	500	400	313	239	176	124	83.2	51.6	39.0	28.6	20.0	13.2	8.1	4.41	2.00	.645	.09
		Velocity in feet per second with 1000 lb. per minute passing at density = 1																
		5.305	6.314	7.640	9.43	11.94	15.09	21.22	30.56	37.73	47.75	62.37	84.88	122.2	191.0	339.6	764	3056

TABLE II.—Flow of Gases in Pipes—High Densities.

Reference Letter.	Pounds per Minute delivered by 24-in. Pipe. For Deliveries for other Diameters see Table I.	Loss of Pressure in Pounds per 100 Feet to Force Quantity Stated, at Density Stated, through 24-In. Pipe. Density of Gas in Pounds per Cubic Foot. .025	.05	.10	.15	.20	.25	.30	.40	.50	.60	.70	.80	.90	1 lb.
		Corresponding Absolute Steam Pressure, Pounds per Square Inch.													
		9.4	19.7	41.2	64	87	110	134	181	230	281	327	375	423	470
		Corresponding Absolute Air Pressure, at 60 Deg. Fahr., Pounds per Square Inch.													
		4.8	9.6	19.2	28.8	38.4	48.0	57.6	76.8	96.0	115 .	134	154	173	192
		Loss of Pressure, Pounds per Square Inch.													
T	20,000	33.0	16.5	8.25	5.50	4.126	3.301	2.751	2.063	1.651	1.375	1.179	1.032	.917	.825
S	19,000	29.8	14.9	7.45	4.97	3.724	2.979	2.483	1.862	1.490	1.241	1.064	.931	.828	.745
R	18,000	26.7	13.4	6.69	4.46	3.343	2.674	2.228	1.671	1.337	1.114	.955	.836	.743	.669
Q	17,000	23.9	11.9	5.96	3.98	2.981	2.385	1.988	1.491	1.193	.994	.852	.745	.663	.596
P	16,000	21.1	10.6	5.28	3.52	2.641	2.113	1.761	1.320	1.056	.880	.754	.660	.587	.528
O	15,000	18.6	9.28	4.64	3.09	2.321	1.857	1.547	1.161	.928	.774	.663	.580	.516	.464
N	14,000	16.2	8.09	4.04	2.70	2.022	1.618	1.348	1.011	.809	.674	.578	.506	.449	.404
M	13,000	14.0	6.97	3.49	2.33	1.743	1.396	1.162	.872	.697	.581	.498	.436	.387	.349
L	12,000	11.9	5.94	2.97	1.98	1.483	1.188	.990	.743	.594	.495	.424	.371	.330	.297
K	11,000	9.99	4.99	2.50	1.66	1.243	.999	.832	.624	.499	.416	.357	.312	.277	.250
J	10,000	8.25	4.12	2.06	1.37	1.032	.825	.688	.516	.413	.344	.295	.258	.229	.206
I	9,000	6.69	3.34	1.67	1.11	.836	.669	.557	.418	.334	.279	.239	.209	.186	.167
H	8,000	5.28	2.64	1.32	.880	.660	.528	.440	.330	.264	.220	.189	.165	.147	.132
G	7,000	4.04	2.02	1.01	.674	.506	.404	.337	.253	.202	.169	.144	.126	.112	.101
F	6,000	2.97	1.49	.743	.495	.371	.297	.248	.186	.149	.124	.106	.0929	.0826	.0743
E	5,000	2.06	1.03	.516	.344	.258	.206	.172	.129	.103	.0860	.0737	.0645	.0573	.0516
D	4,000	1.32	.660	.330	.220	.165	.132	.110	.0825	.0660	.0550	.0472	.0413	.0367	.0330
C	3,000	.743	.371	.186	.124	.0929	.0743	.0619	.0464	.0371	.0310	.0265	.0232	.0206	.0186
B	2,000	.330	.165	.0825	.0550	.0413	.0330	.0275	.0206	.0165	.0138	.0118	.0103	.0092	.00825
A	1,000	.083	.041	.0206	.0137	.0103	.0083	.0069	.0052	.0041	.0034	.0029	.0026	.0023	.00206

TABLE III.—Flow of Gases in Pipes—Low Densities.

Reference Letter.	Pounds per Minute delivered by 24-In. Pipe. For other sizes see Table I	Loss of Pressure in Pounds per 100 Ft. to Force Quantity Stated, at Density Stated, through 24-In. Pipe. Density of Gas in Pounds per Cubic Foot.													
		.0025	.003	.010	.015	.020	.025	.030	.040	.050	.060	.070	.080	.090	.100
		Corresponding Absolute Steam Pressure, Pounds per Square Inch.													
		.8	1.7	3.6	5.5	7.5	9.4	11.4	15.5	19.7	23.9	28.1	32.5	36.9	41.2
		Corresponding Vacuum in Inches.							Steam Pressure on Gauge.						
		28.4	26.5	22.6	18.8	14.7	10.8	6.7	.8	5.0	9.2	13.4	17.8	22.1	26.9
		Loss of Pressure, Pounds per Square Inch.													
t	10,000	82.5	61.3	20.6	13.7	10.3	8.25	6.88	5.16	4.13	3.44	2.95	2.58	2.29	2.06
s	9,500	74.5	37.2	18.6	12.4	9.31	7.45	6.21	4.66	3.72	3.10	2.66	2.33	2.07	1.86
r	9,000	66.9	33.4	16.7	11.1	8.36	6.69	5.57	4.18	3.34	2.79	2.39	2.09	1.86	1.67
q	8,500	59.6	29.8	14.9	9.94	7.45	5.96	4.97	3.72	2.98	2.48	2.13	1.86	1.66	1.49
p	8,000	52.8	26.4	13.2	8.80	6.60	5.28	4.40	3.30	2.64	2.20	1.89	1.65	1.47	1.32
o	7,500	46.4	23.2	11.6	7.74	5.80	4.64	3.87	2.90	2.32	1.94	1.66	1.45	1.29	1.16
n	7,000	40.4	20.2	10.1	6.74	5.06	4.04	3.37	2.53	2.02	1.69	1.44	1.26	1.12	1.01
m	6,500	34.9	17.4	8.72	5.81	4.36	3.49	2.91	2.18	1.74	1.45	1.25	1.09	.969	.872
l	6,000	29.7	14.9	7.43	4.95	3.71	2.97	2.48	1.86	1.49	1.24	1.06	.929	.825	.743
k	5,500	25.0	12.5	6.24	4.16	3.12	2.50	2.08	1.56	1.25	1.04	.892	.780	.694	.624
j	5,000	20.6	10.3	5.16	3.44	2.58	2.06	1.72	1.29	1.03	.860	.737	.645	.573	.516
i	4,500	16.7	8.36	4.18	2.79	2.09	1.67	1.39	1.04	.836	.696	.597	.522	.464	.418
h	4,000	13.2	6.60	3.30	2.20	1.65	1.32	1.10	.825	.660	.550	.472	.413	.367	.330
g	3,500	10.1	5.06	2.53	1.69	1.26	1.01	.843	.632	.506	.421	.361	.316	.281	.253
f	3,000	7.43	3.71	1.86	1.24	.929	.743	.619	.464	.371	.310	.265	.232	.206	.186
e	2,500	5.16	2.58	1.29	.860	.645	.516	.430	.322	.258	.215	184	.161	.143	.129
d	2,000	3.30	1.65	.825	.550	.413	.330	275	.206	.165	.138	.118	.103	.092	.083
c	1,500	1.86	.929	.464	.310	.232	.186	.155	.116	.093	.077	.066	.058	.052	.046
b	1,000	.825	.413	.206	.137	.103	.083	.069	.052	.041	.034	.029	.026	.023	.021
a	500	.206	.103	.052	.034	.026	.021	.017	.013	.010	.0086	.0074	.0064	.0057	.0052

Tables II. and III. give the loss of pressure per 100 feet for the discharges given in the corresponding line of Table I.; Table II. being for high densities and Table III. for low densities. The steam pressure corresponding to each density is stated at the head of the tables.

These tables will be found to meet all the cases arising in ordinary practice, where the diameter does not exceed 24 inches, covering lighting gas, ammonia, saturated steam at pressures from zero up to 470 pounds absolute, and air from zero up to 13 atmospheres. The deliveries covered range from those at which the loss of pressure is inappreciable to the largest for which pipes of the diameters specified can be economically used.

This concentration has only been attainable by the device of grouping upon one line those discharges for different diameters which require the same loss of pressure. The capital letters in Table I. refer to Table II., and the small letters to Table III.

The upper left hand corners of the tables give discharges and losses of pressure much greater than would be adopted in practice; but these figures are not without value in dealing with discharges which are sub-multiples of those given. The loss of pressure being proportional to the square root of the discharge, it follows that the loss of pressure for one-tenth of any discharge given in the table may be obtained by moving the decimal point two places to the left in the loss of pressure given for that discharge. Thus Table III. gives for 9,500 lb. per minute, at density = .0025 in a 24-in. pipe, a loss of pressure of 74.5 lb. per 100 ft. For 950 lb. per minute the loss of pressure per 100 ft. will be .745 lb.

p = loss of pressure in pounds per square inch.
w = delivery of fluid in pounds per minute.
Q = delivery of fluid in cubic feet per minute.
v = velocity in feet per second.
d = diameter of pipe in inches.
L = length of pipe in feet.
D = density of fluid in pounds per cubic foot.
F = loss of pressure in feet of fluid.
H = loss of pressure in inches of water = 27.7 p.
M = loss of pressure in inches of mercury = 2.04 p.

$$p = \frac{w^2 L\left(1+\frac{3.6}{d}\right)}{7{,}000\ D\ d^5} = \frac{Q^2\ D\ L\left(1+\frac{3.6}{d}\right)}{7{,}000\ d^5} = \frac{v^2\ D\ L\left(1+\frac{3.6}{d}\right)}{65{,}360\ d}$$

$$w = \sqrt{\frac{7{,}000\ p\ D\ d^5}{L\left(1+\frac{3.6}{d}\right)}} = Q\ D = \frac{v\ D\ d^2}{3.056}$$

$$Q = \frac{w}{D} = \sqrt{\frac{7{,}000\ p\ d^5}{D\ L\left(1+\frac{3.6}{d}\right)}} = \frac{v\ d^2}{3.056}$$

$$v = \frac{3.056\ w}{D\ d^2} = \frac{3.056\ Q}{d^2} = 256\sqrt{\frac{p\ d}{D\ L\left(1+\frac{3.6}{d}\right)}} = \sqrt{\frac{454\ d\ F}{L\left(1+\frac{3.6}{d}\right)}}$$

$$d = \sqrt[5]{\frac{.0002\ w^2\ L}{p\ D}} = \sqrt[5]{\frac{.0002\ Q^2\ D\ L}{p}} \text{ approximately.}$$

$$L = \frac{7{,}000\ p\ D\ d^5}{\left(1+\frac{3.6}{d}\right)w^2} = \frac{7{,}000\ p\ d^5}{\left(1+\frac{3.6}{d}\right)Q^2\ D}$$

$$F = \frac{w^2 L\left(1+\frac{3.6}{d}\right)}{49\ D^2\ d^5} = \frac{Q^2 L\left(1+\frac{3.6}{d}\right)}{49\ d^5} = \frac{v^2\ L\left(1+\frac{3.6}{d}\right)}{454\ d} = \frac{144\ p}{D}$$

Three tables are given herewith, showing the loss of pressure required to force through pipes of different diameters different quantities of gas of different densities.

Table I. gives proportional discharges for different diameters, the density and loss of pressure being the same for all cases on the same horizontal line.

Weight of gas, rather than volume or velocity, has been adopted as the measure of a pipe's capacity, for the reason that the weight remains constant under all conditions, whereas both volume and velocity change with every change in the temperature or pressure of a gas; and because gases are more often dealt with by weight than by volume. The volume, however, can be readily ascertained by dividing the weight by the density. The velocity corresponding to any discharge can be obtained from Table I., which gives the velocity in feet per second in pipes of the diameters stated, when 1,000 lb. per minute at density = 1 are passing through them. For any other discharge or density, multiply the velocity given in the table by that discharge, and divide the product by 1,000 times the density.

To facilitate reference, the tables are divided by stepped lines into belts of approximately equal quantities and losses of pressure respectively.

The information contained in Tables II. and III. is given in a graphic form in the diagrams bearing the same numbers. These diagrams (pp. 558, 559) are provided with scales showing the pressure of saturated steam or air corresponding to the density shown immediately above them.

In dealing with a gas of a density intermediate between the vertical lines of the diagram, an intermediate vertical can be drawn corresponding to that density, which will give by its intersection with any discharge line the loss of pressure required to deliver the quantities stated on the corresponding line of Table I. Such lines have been dotted on Diagram III. for gas from Newcastle coal and cannel coal respectively, and for air at 60° F. and 1 atmosphere.

In dealing with cases beyond the scope of the tables, or for ascertaining more closely the loss of pressure with a discharge intermediate between those given in the tables, the formulæ must be used.

Where the loss of pressure in a pipe is but a small proportion of the original pressure, no great inaccuracy will result from using the density due to the original pressure, or preferably that due to the mean of the original and terminal pressures, if both are known. But in long mains, where the loss of pressure is very great, a considerable error may result from following this course.

In such cases it is better to ascertain the initial velocity by means of the following formula, adapted from the very valuable formula proposed by Prof. Unwin. Let u = the initial velocity in feet per second,

P_1 the initial pressure, P_2 the terminal pressure, both in pounds per square inch absolute, D the density of the gas at atmospheric pressure, d diameter of pipe in inches, and L length in feet; then

$$u = \sqrt{\left\{\frac{480{,}000\ d\ (P_1^2 - P_2^2)}{\left(1 + \frac{3.6}{d}\right) L\ D_a\ P_1^2}\right\}}$$

The weight of gas delivered can then be ascertained by substituting the value of u thus arrived at for v in the equation

$$w = \frac{v\ D\ d}{3.056}$$

The loss of pressure given by the foregoing tables and formulæ is that for a straight pipe, and does not cover the head due to velocity, nor the loss of pressure occurring at valves, bends and elbows. Where the pipe is long and the obstructions few, these may be neglected, but otherwise account should be taken of them, the most convenient method being to add to the actual length of pipe an additional length in which the loss of pressure is equal to that caused by the obstructions.

The following table, worked out from formulæ given by Mr. Hurst, gives the length of pipe equivalent to a square elbow, and to a bend of 90°, whose radius is equal to the diameter of the pipe. The head due to velocity is approximately equal (actually 2 per cent. more) to the head due to a square elbow. The loss of pressure at a screw-down valve is about 1½ times that due to a square elbow. Messrs. Babcock and Wilcox and Mr. Trautwine give tables for these losses, closely agreeing with Mr. Hurst's formulæ.

Length in Feet of Straight Pipe Equivalent to a Square Elbow and to a Bend of Radius = Diameter.

Diameter...	1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.
Elbow.....	1.5	4.9	9.4	14.5	20.0	25.9	32.0	38.0	44.4
Bend	.23	.74	1.41	2.2	3.0	3.9	4.8	5.7	6.7

Diameter...	10 in.	12 in.	14 in.	16 in.	18 in.	20 in.	22 in.	24 in.
Elbow.....	50.7	63.7	76.7	90.1	104	117	130	144
Bend	7.6	9.6	11.5	13.5	15.5	17.5	19.6	21.6

Observations on Carbureted Water Gas.

[A paper prepared at the invitation of the Civil and Mechanical Engineers' Society, of London, Eng., by Mr. J. T. Westcott, of Toronto, Canada.]

No one can be indifferent to the development of the gas industry, which, within the past few years, has increased to so great an extent that at the present time, in the amount of capital invested, with the exception of railways, it is second to no other industry. Since Murdoch, the recognized "Father of Gas Lighting," first lighted his house in 1793, gas has been manufactured from coal, rosin, wood, oil, coke, steam, calcium carbide, and water, and has also been discovered and used very extensively in the natural state. When found in the latter form, it has proved very valuable for fuel purposes; the burning of 1 cubic foot giving about 225 British thermal units more than can be obtained from the same quantity of 18-candle power coal gas. Usually the terms coal gas, carbureted water gas, water gas, or producer gas, are simply intended to convey a commercial idea, without any technical meaning; and owing to this fact, much misunderstanding has arisen, causing discussions which have misled and prejudiced the public. The term "carbureted water gas" conveys to the people of Great Britain the same meaning that the term "water gas" does to the American mind.

Different Kinds of Commercial Gas.—Coal gas is manufactured by placing bituminous coal in airtight retorts, and subjecting these to a high degree of temperature, thereby expanding the gas contained in the coal, and forcing it out. After leaving the retort it is condensed, scrubbed, purified, etc., before being used by the consumer.

Producer gas is made by passing air, or air and steam together, through incandescent fuel contained in a furnace producer or generator; the highly heated carbon of the fuel uniting with the oxygen of the air and steam, and forming producer gas, which is composed of carbonic oxide, hydrogen, nitrogen and certain impurities, chief of which is carbonic acid. This gas, as we find it manufactured by the Dowson producer, is used principally in factories for fuel purposes. Compared by measure with other gases, it gives, when burning, a low illuminating and heating power; but, when compared by weight, it burns with a high temperature and low illuminating power.

Water gas is formed in nearly the same manner as producer gas, with the exception that steam alone is passed through the incandescent fuel bed. The resultant gas is composed of carbonic oxide and hydrogen, $2CO + 2H_2$, and some impurities.

Carbureted water gas is as different from water gas as day is from night. After making the straight water gas just described, it is passed over a large surface of highly heated refractory material, in conjunction with oils containing hydrocarbons, which are first vaporized and then gasified, and form a chemical composition with the water gas. The new gas thus formed is called carbureted water gas. It is the apparatus for manufacturing this particular form of gas which will occupy our attention this evening.

History of Carbureted Water Gas.—It is most interesting to note the development and evolution of carbureted water gas from its earliest inception. About 1784, Cavendish made the discovery that hydrogen—which had been known before as "inflammable air"—was one of the component parts of water, and at the time it was looked upon as very astonishing. Some while before this, Fontana pointed out that gas could be manufactured by the decomposition of water, in passing it over ignited iron and coal. The theories set forth by these scientists seem not to have been put into actual practice until about 1824, when J. H. Ibbetson took out a patent for a special method of making an illuminating gas by passing steam through a mass of incandescent carbon.

From this time down to 1860, quite a number of different patents were taken out, reaching a total of 60 or more. During this period, however, no apparatus was designed that gave commercial success. It is interesting to note that some of these early patents contained features which are found in our modern successful settings. It is not my intention to deal with the many patents which have been taken out to the present day, as their number is almost legion, or to consider in detail some 30 different types of plant which have been built and put into successful operation. These can be divided into two general classes. Class I., retort processes, or those in which the steam is admitted into retorts containing carbon, the temperature of which is maintained by combustion external to the retorts—such as the Sanders apparatus, the Allen-Harris and others. Class II., generator processes, or those in which the steam is admitted into retorts and furnaces, or generators, containing carbon which has been previously heated by partial combustion of its own mass or by internal combustion.

The latter class can be divided into two sections: (1) The generator processes, in which a non-luminous water gas is first made, which is afterwards carbureted, usually in a second apparatus, by a second fire and in a second operation—such as the Tessié du Motay, the Wilkinson, the Jerzmanowski and other apparatus. (2) The generator processes, in which an illuminating water gas is made, carbureted and fixed entirely in one operation, one apparatus and with one fire, usually through the medium of a superheater—such as the Lowe, the Granger and the Hanlon-Leadley apparatus, and the two types found in Europe—the double superheater and the Merrifield-Westcott-Pearson apparatus.

Professor T. S. C. Lowe is unquestionably the man who has received the credit of inventing the process which is the basis of the present successful commercial water gas plant. The first Lowe apparatus was erected in Phœnixville, Pa., in 1873. After this, for several years, the Lowe apparatus was built by different firms, who obtained licenses from Professor Lowe, down to about 1885, when the Granger Water Gas Company were consolidated with the United Gas Improvement Company. Notwithstanding these various processes, patents, etc., at the present day we find in England only two distinct types—namely, the so called double superheater process, an example of which is The Gas Light and Coke Company's installation of 10,000,000 cubic feet daily capacity, the first sets of which were erected by the United Gas Improvement Company, of Philadelphia. Another example of this class may be seen at Belfast, and still another at Hornsey, each of which was erected by a different firm.

The first double superheater setting for the manufacture of carbureted water gas was erected at Coney Island, U. S. A., in the spring of 1882, and was designed by A. O. Granger & Co. The generator was 6 feet in diameter by 12 feet 3 inches high; the carbureter, 6 feet in diameter by 13 feet high; and the superheater, 6 feet diameter by 22 feet high. It was originally designed to be worked with superheated steam. The generators were to be connected at the bottom, and the oil was admitted at the top of the carbureter by an injector, the necessary force being obtained by a pump under pressure. The consumption of gas being too small, the plant was never operated as designed, one set only being used in the ordinary manner. The constructing engineer for the

contractors was our chief engineer, Mr. L. L. Merrifield. The patent for the first double superheater apparatus was taken out in the United States by A. O. Granger and J. H. Collins, Jr., and was known as a "process of, and apparatus for, manufacturing gas," patent No. 287,277, granted October 23, 1883; application filed March 10, same year.

This type of plant consists of three steel shells. The first is known as the generator, and is connected from the top to the upper part of the second shell, which is called the carbureter; and this is connected at the bottom to the lower part of the third shell, which is known as the superheater, and is usually higher than the first two. Each shell contains a firebrick lining about 12 inches in thickness, at the back of which is a filling-in material of asbestos fiber, or some good non-conducting substance about 2 inches in thickness; on the outside being the steel shell. A branch on the top of the generator admits the coke, which is supported by grate bars at the bottom; and under these bars is a conical shaped hopper, sealed by means of a valve to make it gastight. The other two shells, in addition to the firebrick lining, are filled with a checkerwork of common firebrick, supported on arches or tiles. At the top of the superheater is a branch and stack valve, which regulates the flow of the gases from the apparatus. One reason for first building this style of plant was to adapt it to the low roofs of retort houses then in use. Its rapid progress in the United States was owing to the United Gas Improvement Company controlling the Lowe patents, and for commercial reasons introducing it, without practically any competition with any other form of plant; whereas, in Canada, where different conditions exist, there have been five of some form of the combined type erected for every one of the double superheater type.

It is worthy of note that some of the people who have had large experience with this type of plant have discarded it for the second type—viz., the Merrifield-Westcott-Pearson apparatus—which is now being introduced into Great Britain by the Economical Gas Apparatus Construction Company, and embodies the latest development in the evolution of carbureted water gas plants. Parties who are very good as writers and theorists have tried to demonstrate theoretically that the old style of plant should be adhered to—possibly because the new one is covered by patents. The reason for abandoning this plant was owing to its inability to deal efficiently with the gasification of all grades of oil, especially the heavier ones found in Canada and England. For best practical results, this oil requires a low heat, which the double superheater fails to give, owing to the oil first coming in contact with either the brickwork or square iron bars at the top—*i.e.*, the hottest part of the carbureter, caused by the radiated heat from the generator, and the producer gas continuously burning at this point when blowing up the heats. In practice, it is found impossible to keep this heat at the low point required for the best distillation of the oil; the high heat causing a large percentage of lampblack. Its thorough mixture with the straight water gas is retarded by both passing down through the carbureter.

At times the oil disintegrates the brickwork, and destroys the steel shell at the bottom. Practically the only part of the apparatus that acts as an efficient gasifier for the oil is the superheater. When blowing up the heats, dust and small particles of coke are frequently carried from the generator into the refractory material of the carbureter, rendering it inefficient and requiring it to be renewed at an early date. The oil heater, being placed between the outlet of the superheater and washer, soon clogs up, owing to a deposit of lampblack. The great percentage of carbonic acid which is made in the generator, places a very heavy amount of work upon the purifiers. The floor space and distance between the valves give the gas maker unnecessary work. The connections between the generator and carbureter are practically a return to an obsolete and discarded form of plant, known as the goose-neck connection.

The practical and theoretical experience gained by men who have had as much, if not more, experience than any others, has overcome many of the above objectionable features by designing and building the newest type of plant, which may be termed the combined form.

The Merrifield-Westcott-Pearson Setting.—Of the various types of the combined form of apparatus, there have been some 230 sets built. This particular type may be seen, among other places, at Blackburn and Birmingham; the latter plant when completed having a daily capacity of from 8 to 10 million cubic feet. It consists of two shells—(1) the generator, and (2) the superheater and fixing chamber—with direct connections between them, only 20 inches apart, having brickwork linings similar to that previously described in the double superheater type, with stack valve, etc. The superheater is the lower part of the second chamber, and superheats the water gas before it comes in contact with the oil. The fixing chamber is the top part of the second shell. The superheater is filled with common firebrick checker, supported upon tiles; and then there is a space between the top of the checkers to another arch above it, which is below the level of the working floor, where the oil is admitted. This space may be called the carbureting chamber. Directly above this is an arch supporting the checker bricks of the fixing chamber where the straight water gas and oil are literally cooked into a permanent gas. When blowing up the heats, the air is admitted into this second vessel at two different points, and they are so nicely adjusted that almost any temperature at any part of the apparatus can be obtained at the will of the operator—thus ensuring the most efficient and best results from the oil, giving them the different heats that may be required for any grade of oil in use, and admitting the oil to the coolest part of the apparatus. The oil, forced downward through the atomizers, impinges the straight water gas as it ascends, causing the two to mix in the most thorough manner, and thus preventing the undesirable collection of oil on the bricks, which would be burnt out when blowing up the heats. The brickwork is kept clean, and in most efficient working order, by passing all foreign matter that may blow over from the generator to the bottom of the superheater, where it is taken out from time to time through a manhole, and never allowed to come in contact with the brickwork. The parts are so nicely adjusted that practically no lampblack is made, thus ensuring better illuminating results. The water in the washer is always kept at a high temperature, in order to prevent sudden cooling of the gas. The generator is specially arranged to give several different zones of heat, so as to keep down the amount of carbonic acid.

Method of Operation.—A fire is started in the generator, which is filled up with coke. A blower is started by means of an engine, making a forced draught into the fire at the bottom of the generator, the main being regulated by a valve. The coke becomes hot, which gives it a strong tendency to unite with the oxygen of the air, forming producer gas—that is, carbonic oxide and nitrogen are set free. These two gases pass out at the top of the generator down to the bottom of the superheater; and as they are only partial products of combustion (the meaning of which is that if more oxygen is added while they are in a heated state, they will ignite and burn), air is admitted at this point, regulated by a valve controlling the amount supplied from the fan, and the carbon from the carbon monoxide grasps the oxygen of the air, forming some carbonic acid, and leaving some carbonic oxide and nitrogen. The amount is varied according to the heat required. These gases pass on up through the superheater and carbureting space to the fixing chamber, where another valve is opened and admits air to the fixing chamber, the oxygen of which unites with the remaining carbonic oxide and forms carbonic acid, setting a further amount of nitrogen free. With the absorption of this large amount of oxygen from the air, heat results. The coke becomes heated, and the carbonic oxide absorbing the oxygen in the superheater and fixing chamber, there is an intense heat, which is absorbed by the series of loose firebricks with which the superheater and fixing chamber are filled. These are the products of complete combustion, which pass up through the stack valve to the atmosphere. As soon as we have obtained sufficient heat from the decomposition of steam in the generator, and the best heats in the right places in the superheater and fixing chamber, we discontinue the process of blowing up the heat which has just been described, and commence.

Making a Run of Gas.—The air blast is shut off from the fixing chamber and superheater and generator, and combustion ceases. The stack valve is closed, and steam is admitted under the grate bars of the generator, the highly heated carbon of the coke decomposing the steam by uniting with the oxygen and setting the hydrogen free, forming theoretically $2CO + 2H_2$. In practice, however, there are some impurities and a certain amount of carbonic acid. These two gases form what is known as straight water gas, and will burn with a pale blue light. The illuminating power is produced by the oil being forced through the atomizers as before described. As the water gas passes up through the superheater, the oil is vaporized and gasified, and the two gases thoroughly mixed; and it passes up through the hot firebrick of the fixing chamber and forms a thoroughly fixed permanent high candle power gas, known as carbureted water gas. From here it passes on through the washer and oil heater, where the otherwise wasted heat is taken up by the oil which is passing in an opposite direction to the gas through a coil. From here the gas flows on through the scrubbers, condensers, purifiers, etc. When it is time to stop the run of gas making, the oil and steam valves are closed, and the stack valve opened.

Making a Down-Run.—To again regain the heats, we proceed in like

manner as previously described. When all is ready to make the down run of gas, we close the air valves and stack valves, and simultaneously shut the valve regulating the upper outlet of the generator, and open the valve regulating the outlet at the bottom of the generator. Steam is now admitted at the top of the generator, and passes down through the fire on over into the bottom of the superheater; the same chemical reactions taking place in the formation of the water gas in the generator as previously described. After this the water gas is passed on, and comes in contact with the oil in the same manner as with an up-run. The same chemical reaction will be taking place in the formation of carbureted water gas as has already been described. Frequently we make 5-minute blows and 7-minute runs.

Analyses.—The following is an analysis of the unpurified gas from the Blackburn plant on this system. Candle power, 22.7.

Sulphureted hydrogen	0.6 per cent.
Carbonic acid	2.8 "
Unsaturated hydrocarbons	10.3 "
Oxygen	0.1 "
Carbonic oxide	27.1 "
Saturated hydrocarbons	22.3 "
Hydrogen	29.4 "
Nitrogen (by difference)	7.4 "

The following is an analysis of the purified gas taken from the same plant at another time. Candle power, 21.37.

Carbonic acid	—
Oxygen	—
Olefines, etc.	13.9 per cent.
Marsh gas, etc.	26.2 "
Carbonic oxide	22.7 "
Hydrogen	32.8 "
Nitrogen	4.4 "
Density	0.592

In order to show the analogy of this gas with coal gas, I append the following analysis of coal gas taken from the Minutes of Proceedings of the Institution of Civil Engineers, Vol. LXXIII., p. 320:

Carbonic acid	—
Oxygen	0.08 per cent.
Olefiant gas	3.53 "
Marsh gas	35.25 "
Carbonic oxide	8.95 "
Hydrogen	51.81 "
Nitrogen	0.38 "
Density	0.458

From these analyses, it will be observed that coal gas and carbureted water gas, though made by two totally different processes, in the finished product are analogous.

Rapid Increase of Water Gas in America.—Notwithstanding the legal and technical contentions that have taken place in America, and almost everything possible done to prohibit the manufacture of carbureted water gas, still within the past 20 years it has increased so rapidly that at the present time 70 per cent. of all the gas made is carbureted water gas, leaving only 30 per cent. of coal gas. In many leading towns—Chicago, Boston and other places—it is consumed in its pure state, without being mixed with coal gas.

Scientific Opinions.—It will be unnecessary for me to quote the opinion of the leading scientists the world over on the advisability of the use of carbureted water gas, further than the following from Dr. Crum Brown, Professor of Chemistry at the University of Edinburgh. After comparing the two gases, he concludes by stating: "The increased amount of carbonic oxide is therefore no real objection to the introduction of carbureted water gas for illuminating purposes in place of coal gas;" and Dr. E. Frankland, formerly Gas Examiner of London, writes from the Royal College of Chemistry, South Kensington, London, dated May 16, 1878, as follows:

In compliance with your request, I have read the reports of Dr. Henry Wurtz, dated Jan. 1, 1878, and March 4, 1878, on the composition and properties of the gas of the Municipal Gas Light Company, of New York, and also the articles published by Professor Henry Morton in the AMERICAN GAS LIGHT JOURNAL of March 2 and 16, 1878; and having been called upon to express my opinion as to the adaptability of water gas for lighting and heating purposes, I have no hesitation in saying that it may be used with safety, both in public buildings and in private houses. I should be delighted to substitute this pure and powerful illuminating agent for the gas with which my house in London is at present supplied, although it is used in all the bedrooms.

It would seem that many people when comparing the two gases forget that the cause of a person dying from asphyxiation is want of oxygen; and when they have been compelled to breathe marsh gas or carbonic oxide, that the microscopical examination of the corpuscles of the blood from the effect of either is the same. It would seem that, though there is a greater amount of carbonic oxide in carbureted water gas than in coal gas, yet in coal gas there is a much larger amount of marsh gas than is found in carbureted water gas—the one offsetting the other in its ill effects. The general conclusion where this gas has been extensively used is that for illuminating purposes the one is no more dangerous than the other.

Use of Carbureted Water Gas.—As an Enricher.—The rapid increase in the amount of carbureted water gas consumed in America is owing greatly to its enriching value, and to the fact that a gas of 30 candles can be made and used in its pure state. This was found necessary in order to compete with the electric light. As an enricher, it is one of the best, if not the best, known. A high candle power gas can be made proportionately at less cost than low candle power gas. For instance, the amount of labor and coke required per 1,000 cubic feet to manufacture a 16-candle gas is precisely the same as that needed for the manufacture of a 30-candle gas; the only extra cost being the additional amount of oil required.

Clogging of Burners.—Some trouble has been experienced from the clogging of burners when using this form of gas. The same is also true of coal gas, and is only found when either gas is not thoroughly purified or condensed. With proper precautions, there is never any trouble whatever from the clogging of burners.

Gas Engines and Heating Purposes.—Carbureted water gas when burning gives off about 5 per cent. less heat than coal gas of the same candle power. This difference is usually counteracted by making a higher candle power carbureted water gas than is generally made when manufacturing coal gas. There is no trouble from its use for power purposes in gas engines, or for cooking and heating purposes in stoves. Perfect satisfaction can be obtained from perfect combustion, which is attained by regulating the amount of air supplied to the gas; carbureted water gas requiring a little less air than coal gas.

Cost of Manufacture.—A paper written by the Blackburn Corporation Engineer, and read before the Manchester District Institution of Gas Engineers, gives the amount of raw material required for 1,000 cubic feet of carbureted water gas as shown in the next table.

Gas made	5,129,000 cubic feet.
Oil used	16,773 gallons.
" per 1,000 cubic feet	3.26 "
Coke used (generator and boiler)	188,113 pounds.
" " " per 1,000 cu. ft.	36.70 "
Illuminating power	23 24 candles.
" " per gallon	7.10 "

This was the actual average working of one section of the plant from October 23 to November 13, 1895. In addition to the cost of raw material, the wages per 1,000 cubic feet for the same time averaged 0.77d.

Thermal Value.—When we consider this type of plant from a thermal standpoint as a heat engine from actual tests, it stands among the first; and with the gradual evolution that is taking place, each year is adding to its efficiency thermally, and also as a chemical apparatus.

Advantages of Carbureted Water Gas.—These are so well understood that only a reference will be necessary:

1. The small ground space required; about 2,500,000 cubic feet of carbureted water gas being manufactured in the space required for 600,000 cubic feet of coal gas.
2. Its immediate availability. Without injury, a cold plant can be making gas within four hours from the time of firing the generator.
3. Saving in capital account.
4. Control of the coke market.
5. Candle power increased or decreased instantly.
6. Assistance in times of strikes; one man making the same amount of gas as eight or ten men in a coal gas works.
7. Assistance in case of dearth in coal supply, by making use of coke.
8. Destroys and prevents naphthaline deposits.
9. Reduces the cost of manufacture of coal gas.
10. Saving in repairs and maintenance.

That these advantages have been appreciated is demonstrated in America by the amount of carbureted water gas used, and in Europe by its adoption at the works of many of the leading engineers. In every place the advisability of adopting carbureted water gas must be determined by the peculiar local condition. From personal experience, the ideal plant is that which combines both coal and carbureted water gas.

The Production of Coal: Its Consumption and Cost.

Engineering says there are many objections to the acceptance of the view, too readily entertained sometimes, that the consumption of coal per head of the population offers reasonable basis for a comparison of the material progress of the people. Thus, when it is pointed out that they in Great Britain use 3¾ tons *per capita* against a tenth of a ton per inhabitant of Russia, it must be remembered that much wood is used for domestic purposes and much oil as mechanical fuel in the land of the Czar. The same influences are more or less operative in the United States of America, yet the consumption is 2.44 tons per head of population. Again, in Sweden, where barely half a ton is used *per capita*, the innumerable cataracts which give beauty to the mountain scenery have been utilized as power producers by the interposition of the mill wheel, so that water power plays an important part in the production. The same is more pronouncedly the case with Switzerland and Norway, but the Board of Trade return does not give the exact figures for these countries. With Germany, France and Belgium, the only point which confuses comparison is that more wood is used in the home fire, but withal it is gratifying to note that these nations, our chief competitors in industrial enterprise, are far behind us in the volume of coal consumption, and even in view of the limitations indicated it may be accepted that Britain and the United States occupy the foremost position. As we have said, we burn 3.75 tons, Belgium 2.56 tons, Germany 1.38 tons, France 0.95 tons, and Austria-Hungary 0.33 tons per unit of population. Climate and its temperature is another influence, and this accounts for some small part of the low rate in Spain and Italy, 0.19 and 0.15 tons respectively.

Perhaps a more legitimate comparison might be made by taking the records of each individual country for the latest year as against those for 12 years ago. Conditions do not much change from year to year, although the progress in engineering towards the higher economy of engines may affect the result in some countries more than in others. Although our coal is cheaper than in most countries, as we shall presently show, greater efficiency is striven for. Again, the practice of using gas intermittently in the kitchen in the summer months instead of a coal fire continuously, also militates against a greater consumption than formerly, so that the fact that we have not increased our rate *per capita* more than 2 cwt. or so is not unsatisfactory, since there can be no question of the extension of mechanical power in the same 12 years. Germany has improved her consumption from 1.06 to 1.38 tons, and if details were possible, it might be found that much of this is due to the greater iron production. The price of coal does not seem to differ much in its fluctuations with that in Britain. Belgium has gone up from 2.45 to 2.56 tons, France from .81 to. 95 tons, Russia from 0.06 to 0.10 tons. The changes in the other countries in Europe seem to be even less than in this country. In Japan, however, there is a step forward from .02 to .06 tons, marking only a beginning. When we turn to the United States, we have a decided advance from 1.91 tons to 2.44 tons *per capita*, and here one naturally finds the reason largely in greater iron production, more extensively used mechanical power, and perhaps in the less quantity of natural gas fuel available.

This method of comparison *per capita* has its advantages and disadvantages. The individual needs are recognized, and it suggests the amount of heat or energy in one form or other which is available for the population. But the casual reader, who forms such a large proportion, fails to grasp the suggestiveness of such an apparently insignificant increase as half a ton per inhabitant in the United States of America. It means that the coal used has increased in amount from 102 to 170 million tons; that this additional 68 million tons is equal to running throughout the working year of machinery requiring 1,700,000 indicated horse power, or to assisting in the production of 70 to 75 million tons of iron. There is this point, too, worth noting, that the United States has by this progressive increase excelled Britain. Their total is now 170 millions, ours 146¾ million tons. Again, Germany's increase is from 49 to 72 million tons. We are not nervously apprehensive, but it is right to state that for each ton of coal Germany used 12 years ago we burned three, while now we only burn two for her one ton. Our increase of only 12 million tons indeed, seems to suggest that we are approaching the maximum, but as we have already hinted, it will be satisfactory if, while maintaining our total of 147 million tons, we can increase its utility by gaining a larger measure of energy per ton. There is, however, some satisfaction still in the fact that the consumption in all Europe only exceeds that of our small insular kingdom by about 15 million tons, so that, even making liberal consideration for the wood or oil fuel or water power, available in the other countries, we stand pre-eminently the first manufactnring power in the Continent.

Consumption is, however, not to be confused with production, and here we still excel even the United States, although it must be confessed that they are moving steadily forward here also to first position. In 12 years we have increased our output from 163¾ to 189.6 million tons, the United States from 102.8 to 172½ million tons, the increase in the one case being 26 and in the other 70 million tons. They have not, however, entered in any seriousness upon the export trade—their shipments are 2½ million tons; but in this fact there is not much satisfaction for us. It would be better for us if we could utilize still more of our coal rather than send such a surplus as 43 million tons to other countries. What we want to export is manufactures, not raw material. Of course, much of this coal goes to our colonies, but over 18 million tons go to Europe, a large part probably to support competitive manufactories. Germany has increased her production practically as much as Britain, from 55.94 to 79.16 million tons, or 24¼ million tons, and at the same time has not increased her exports of coal, while we have increased our exports from 29½ to nearly 43 million tons. Of course in speaking of exports we deduct such quantities as have been imported. Belgium has increased her output only slightly from 18.1 to 20.4 millions, but has not increased her exports, which amount to about 4 million tons per annum.

France really comes third amongst European countries, although, unlike the others, she has to import some of her fuel. Her production has increased in 12 years, 7 milllion tons, being now 27½ million tons, but she still has to import 9 million tons. Twelve years ago the imports were 10 million tons, so that the greater output is almost entirely absorbed at home. Austria-Hungary is in about the same position, although she has not increased her output to the same extent, and has therefore had to import more. Thus the production increased by 2¾ millions to 10¾ millions, and the imports from 1¾ to 4¼ millions, so that 5½ millions were more actually consumed. We have already indicated the proportional increase in coal consumption in Russia. The amount used has grown from 6¼ to 10¾ million tons, and the greater part of this increase is from Russian mines, the output having gone up from nearly four, to 8½ millions, while the imports have remained almost stationary. The difficulties of transport have probably much to do with the problem here. Either mining will be more encouraged by improved means of distribution, with a consequent extension of manufactures, or increased importation will serve the same desirable end by the same necessary means. Spain is using about 3½ millions, about 33 per cent. more than 12 years ago, half of it produced at home and the other half imported. The greater part of the increase is accounted for by mining in Spain.

Turning now to our colonies, we find that the total production in Australasia has increased from 3 to 5 million tons, while the consumption has only increased from 2.1 to about 3½ millions. Excepting New South Wales, the several colonies seem only to use about half a ton *per capita*, and they import considerble quantities. New South Wales uses nearly as much as all the others put together—1,572,732 tons; but she exports over 2 million tons. Her export trade has grown at the same rate as the production, so that the consumption 12 years ago was 1.17 tons *per capita;* it is 1.23 tons now, less, however, than it was five or six years ago, so that it can scarcely be said that much progress has been made with mechanical power. In India the output has grown in the period under review from 1.3 to 3½ millions, while the imports have remained at 700,000 tons; but the increase of nearly 2½ millions to consumption is only equal to the growth in population, so that there has not been much improvement. There is abundant room for more. In Canada the output has practically doubled, and the imports have grown proportionately, the one being now 3½ and the other 2 millions, so that the Dominion uses fully 2½ million tons more of coal than 12 years ago. In the Cape of Good Hope they only use 201,548 tons—three-fourths imported.

It will therefore be seen that the countries which assist their less fortunate neighbors in making up their deficiencies in fuel are the United Kingdom, to the extent of 43 millions: Germany, 7.2 millions; Belgium, 4 millions; Japan, United States, 2½ millions; and New South Wales, 2.16 millions; and it is, perhaps, interesting to note the cost of producing the coal in these countries. The United States is lowest; the latest returns show that it was only $1.19 per ton, which is about the cost in Britain in 1887. Now it is $1.51 here, and should the States maintain the price of $1.19 it is quite possible to conceive that she will quickly take a higher place as an exporter. As it is, the lower price must have a powerful influence in increasing mechanical power and in cheapening manufacture—two synonymous terms. Germany, as a rule, moves in sympathy with Britain, although for the latest year the value at the pithead is $1.70. Belgian coal seems always to cost more, notwith-

standing that it is per metric ton. It is $1 88. In France the cost is put at $2.20; in Hungary, $2.19; in New South Wales, $1.35, and in the other colonies it varies from $2.04 to $3.06.

Of the countries with a plethora of coal the United Kingdom seems to have the lowest price, excepting the United States, which is probably not yet in a position to export. It is true our price is only 19 cents per ton less than Germany's—and often not so much, but they have not much coal to export. It thus follows that by reason of our low price we have the larger part of the European markets. Thus we send 17 per cent. of the coal consumed in all Russia against 4 per cent. sent by other countries; while 87½ per cent. of the coal burned in Sweden is from British mines. Even Germany has for special trades to take 4 million tons from us, or 5.58 per cent. of her total supply; Belgium also takes 2 per cent.; France 4¼ millions, or 11¼ per cent.; while half the coal consumed in Spain goes from British ports, and 88.71 per cent. of that used in Italy.

The less cost of winning the coal in the United States is probably in part due to the more extensive adoption of machinery, which results in 450 tons being produced per person employed. In New South Wales, where the cost of production is correspondingly small ($1.35), the output per worker is 402. In the United Kingdom it is 276 tons. This proportion has been steadily decreasing. In 1883 it was 347 tons. Since then the hours of labor and other influences have been at work, and although the drifts are now longer and deeper, improved machinery probably makes up partly for the decrease in manual work. In Germany the average output is about 260 tons; in Belgium, 172 tons; in France, 205 tons; and in Austria, 178 tons. In other words, the British miner is the only one who has materially reduced his yearly output; in the case of others it is stationary, or has, as in the States, greatly increased.

The Prevention of Fires Due to Leakage of Electricity.

[A paper read by MR. FREDERICK BATHURST, A.I.E.E., before the Society of Arts, England.]

Introduction.—It is scarcely 16 years ago since the attention of the fire insurance offices was first directed to a class of hazards previously unknown to them, viz., the danger to property arising from the use of electric current for furnishing power and light. The currents which then came into use were proportionately immensely larger than those previously used for telegraphic and other purposes, and now represent possibilities of energy which can be measured only in hundreds of horse power.

Many will still remember the "danger scare," created about the year 1880 or 1881, upon the introduction of electric lighting by reason of the crude methods of wiring which were first adopted. Science and art, however, are in their nature necessarily progressive, and necessity has encouraged improvement and invention. In respect of electric wiring the increase in the demand for electric light has provided wider experience and demonstrated new wants. Public confidence has gradually become re-established, and it is now felt that the elements of great hazard are not necessarily inherent in all electric work, and that fires are preventable within the limits of ordinary wiring practice.

As this improved state of affairs must be ascribed, more or less, to the initial action taken by the various insurance companies—who ostensibly, for their own protection, posed as authorities, took the reins of guidance, and produced "rules" for the purpose of ordering "safe wiring"—it may perhaps seem somewhat inconsistent to suggest that their rules may now even bar the way to further progress. Consideration of this paper may, however, show that in the light of increased experience and with the lapse of time, conditions are arising which prevent the rigid and consistent enforcement of the rules, and so failing to provide perfect safety and reliability, they are becoming antiquated and inoperative.

Although we are having fires caused by electric agency, of recent years we have escaped those of such a nature that public attention would be called to them, and confidence as to the relative safety of electric light has been secured. This acknowledgment becomes all the more desirable for us to retain when it has to be admitted that even with our restored reputation, there still lurks ominously in the public mind an undefined presentiment that electricity and electric fittings of all kinds are in some way "dangerous"—if only as presenting to the lay mind the possibility of an accidental shock.

It must, however, always remain a matter of congratulation that the early action on the part of our fire offices has so far enabled the electrical industry in England to escape the effect and criticism which would arise from the frequent occurrence of insidious and destructive fires caused through defective electrical installation work.

The problem of *safe wiring* is therefore of the utmost importance, and involves the main interest and welfare of the electrical industry. The writer will seek to prove that the greatest "safety" is to be found in adopting the best means of securing and maintaining "perfect insulation," so that it becomes necessary to enumerate the principles that we have to follow, and to ascertain the conditions under which they have to be applied.

Perhaps before proceeding in our review of the present methods of wiring it will be helpful to take a momentary retrospect of the development of an analogous service, viz., that of gas. When gas was first introduced, many crude methods of installation were adopted, such as glass tubes, tinned iron, or copper pipes. These practices gave the needful experience which ultimately led up to the employment of iron pipes, the use of which, indeed, sprang from the utilization of old worn-out gun barrels, until the increasing demand for gas stimulated the production of wrought iron pipes.

King's treatise on the "History of Gas Lighting" states that gas piping service was at first very costly and cumbrous, and remained so until Whitehouse, in the year 1825, took out patents for improvements in the manufacture of wrought iron pipe, and produced it by machinery. It was the lower first cost of installation due to this improvement in production of gas pipes, which afforded means for the general advancement of gas lighting, as it is on record that the chief impetus in gas consumption dates from the year 1830; that is the time when Mr. (afterwards Sir) James Russell took over Whitehouse's works and patents and largely increased the production of low cost iron gas piping.

Conditions.—In order to compare the practice of "gas piping" with "electric wiring," we have to bear in mind the anomaly that electricity needs, instead of an orifice, a solid *material* as its conducting channel. The metal *copper*, owing to its good electrical conducting properties, has by universal consent become the favorite material to employ.

A length of copper wire affords a simple means of transferring electrical energy from point to point.

This energy, according to the transmuting device employed, may be caused to show itself as light, power, heat or chemical action. A part of the energy thus transmitted disappears in the conducting wire itself, according to the opposition or "resistance" offered. This resistance varies directly as the length, inversely as the cross section of the conductor, and according to the specific conducting capacity of the material used, each conducting material possessing its particular specific resistance. Metals have, as a rule, the least resistance and are therefore usually selected as conductors. The portion of energy dissipated in the conductor because of its resistance really reappears in the form of heat, which action increases the temperature of the conductor above its surroundings, and unless the size or "sectional area" of the conducting medium is properly proportioned to the energy to be carried, this heating action may, from a fire-risk point of view, become serious—an over-taxed wire readily becoming hot enough to set fire to any inflammable material in contact with it. The conventional safe working current for copper wire has been fixed at 1,000 amperes per square inch of cross sectional area. The energy it is possible to pass through a wire is dependent upon the pressure or "voltage" at which the electrical supply is effected, and is measured by the product of the pressure or "voltage" multiplied by the ampere flow of current. The pressure of "voltage" which represents such an important factor in electrical supply may, by the non technical, be taken as representing the power of the current to force its way along the conducting path by overcoming the resistance. The "voltage" also determines the ability of the energy transmitted to break through any environment or "insulation" which has been provided for the purpose of confining the current entirely to its conducting path.

As in the case of fluids where suitable pipes must be made and joints provided with a due consideration of the pressure they have to sustain, so also in electrical service—the metallic conductor has to be regarded in respect to these conditions, for, as "pressure" can burst a pipe, so "voltage" can puncture or pierce insulation.

Silk, cotton, rubber and other insulating coverings have been placed upon wire for the purpose of confining the current to its proper path. These materials, in comparison with a metal like copper, are such poor conducting mediums in themselves that they may be termed non-conductors or "insulators." The function of all insulators is to surround the conducting path with a non-conducting wall so as to prevent any extraneous deviation or "leakage" of current between the point of generation or supply and that of utilization.

We see then that in the analogy between gas pipe service and electric

wire service, it is the frail *insulating covering* of the electric wire which corresponds to the substantial *metallic coat* which forms the gas pipe.

Since in every electrical path or circuit we have a pressure or voltage constantly striving to break through the insulating covering, it is evident that the problem of safe and effective wiring is to secure and maintain *perfect insulation* for the conductors throughout their length and treatment. It becomes necessary, therefore, to study the nature and conditions of the insulating materials available.

Speaking generally of insulating materials it is found that the influence of "moisture" upon them is very deleterious; for moisture being itself a conductor, causes any insulating material absorbing it to lose its insulating property. A current leaking through a moisture permeated insulating material produces heat, the material itself becomes charred, and entirely loses its insulating properties, all its specific virtue being ultimately destroyed.

As an insulating covering may be subjected to the influences of heat, arising from the conductor itself carrying excessive current, it is obvious that we should use an insulating material which is little affected by heat, although we find that our choice has to be modified by the consideration that heat resisting materials are usually very great moisture absorbents.

In practice, moreover, insulated wires may be subjected to rough usage: it is important, therefore, to find materials which have sufficient inherent strength to withstand the physical vicissitudes.

In buildings, wiring is everywhere adjacent to wood or brickwork, or in contact with plaster and cement. These building materials, when dry, may be classed as insulators; but if damp, they are, on the contrary, fair conductors, and able to act upon the insulating covering chemically, so as to eventually destroy its insulating properties. A current leakage into plaster or brickwork at some one point may not in itself cause serious damage, but the fact of its having "earthed" a portion of the circuit makes it hazardous for the same occurrence happening in another place. If leakage only presented a temporary interference to the working of an installation and the convenience of the user, it still should be avoided; but experience also shows that when backed by a dynamo and steam engine, sufficient heat energy can be developed to cause a fire. Time, heat, cold, chemical action and moisture are all powerful influences that may tend to deteriorate any of the insulating materials in use commercially; whilst, in addition, accidental damage of the material in the process of manufacture or installation must also be reckoned with.

Incipient electrical faults, such as above referred to, are not readily detected—usually only when a sensational notice of the defect is given. This possibility therefore further accentuates the necessity of insisting upon *good work* and the *right conditions* to start with.

An insulator to be perfect should be one that will keep its insulating properties under all conditions of temperature, being non-corrodible, durable, moisture proof, fire resisting and a reliable armoring. This combination of qualities is at present only partially provided in commercial work, and considering the growing tendency to increase the voltage of supply, this "insulation" problem represents a strife between the power of penetrating and the power of resisting with an all too favorable possibility on the side of penetration.

Experience.—The first electric wiring was done with wires very inadequately insulated and these were usually fastened directly against the nearest convenient support, with iron staples, brass saddles, or later with wooden cleats. If the insulation was not mechanically damaged nor the wires overloaded, and everything was kept quite dry, trouble would not perhaps be immediately experienced, but the natural moisture of the atmosphere or accidental conditions soon caused imperfections.

The leaking current could set fire to the partially insulating materials by gradually consuming minute particles, until the semi-conducting gases so generated would combine into a destructive "arc;" or if leakage occurs between wire and wire a "short circuit" would be created so as to cut the translating devices out of action, and allow the whole current to pass through the defective point.

The heating effect of the current increases directly as the square of its ampere value, so that the amount of heat generated by the short circuit rush of current at the defective point can become very great, sufficient indeed to melt the conductor itself, and set the immediate surroundings on fire.

It is true that we seek to gain protection from such hazards by the use of "Safety Fuses"—thin strips of tin, or easily fusible lead alloy wires—which melt and volatilize when an excessive current is passed through them, and so automatically form a break in circuit, and a means of disrupting the current. Such fuses are are arranged in non-combustible containing chambers, usually earthenware, which will not be damaged by the momentary heat generated by the arc when the fuse melts. A "fuse" is designed to give protection against overloading a circuit; it has, however, its limitations. An abnormal current takes *time* to heat the fusible metal to melting point, thus introducing an element of uncertainty. Furthermore, a fuse does not give protection against a *leakage* of current less than that required to fuse it. In other words a fuse so small as 5 ampere capacity will not prevent a 4 ampere leak, whereas with favorable conditions a leakage current of 2 amperes can cause a fire.

Early wiring work was also defective in respect to design and workmanship, the electrical distribution being effected on what is known as the "tree" principle, in which a main wire feeds branch wires, and these again feed still smaller wires. Construction of this sort necessitates the use of a large number of fuse points and electrical joints, fuses being provided wherever it is necessary to make a junction of a small wire with a larger one. The joints presented many chances for imperfect work, and unless carefully made would give trouble. If two wires are joined together the electrical resistance of contact depends upon the perfection of the union, a slight or partial contact, say on account of rough or dirty surfaces, may mean high resistance, resulting in the production of excessive heat. The insulation of the joint is also an operation which requires care and experience, in order that the new insulating covering should be perfectly waterproof and mechanical, and correspond in effectiveness to the original protection. Carelessness in handling wires, besides damaging the insulating covering, may, in the case of a brittle conductor, result in partial fracture of the copper under the insulating coating. Under these conditions the wire may become heated, and an arc occur at the ruptured ends which can set fire to the insulation. Wires, again, which are too small for the current they are to carry, become over-heated, or the same result is attained if translating devices are changed or increased whilst the "fuse" has been purposely changed or strengthened to allow the increased current. Accidental contact of an imperfectly insulated wire carrying a relatively high voltage, with another designed for low voltage, can result in damage to the latter. The improper placing of wires, or lamps, or the defects arising from poor and defective contact of binding posts and switch terminals, can all become fruitful sources of trouble, and swell the number of conditions by which electrically caused fires may result.

Most insurance companies preface their rules for electric wiring by reciting the principal sources of danger to be anticipated, including them under the following headings:

1. Inferior material and workmanship, particularly in joints, fittings and connections.
2. Conductors of inadequate size and conductivity.
3. Perishable and inferior insulating materials.
4. Dust, dirt and moisture.
5. Undue heating.
6. Neglect of frequent testing and inspection.

In the light of our previous examination of the possibilities by which electrical fires may ensue, we see that these conditions might be broadly summarized as troubles arising mainly under three headings:

1. Imperfect insulation.
2. Imperfect conductivity.
3. Imperfect workmanship.

[To be Concluded.]

Calcium Carbide.

When calcium carbide first made its appearance as an industrial product, one of the uses suggested for it by some of its over enthusiastic advertisers, was a source of power for motors. There has now been time to examine the possibilities of calcium carbide in this direction, and the *Journal de l'Eclairage au Gaz*, 1896, pages 266 to 268, contains the accounts of some experiments by M. Ravel that are of great interest in this connection. As regards the explosive properties of mixtures of acetylene and air, the range is found to be from 4.7 per cent. up to 57 per cent. by volume of acetylene; whilst the maximum force is developed with a volume percentage of acetylene of 7.8. This is a wider range of explosive properties than is found in mixtures of coal gas and air. The maximum rate at which the flame travels through the mixture of acetylene and air is also much in excess of that found in the case of coal gas, and this gives to the explosions a detonating character. The ignition temperature of acetylene is 480° C.; that of coal

gas is 600° C. The temperature of combustion of a 50 per cent. mixture of acetylene and oxygen, is 4,000° C., 1,000° C. higher than that of the oxy-hydrogen flame. It is interesting to compare with this temperature that obtained by Moissan in his electric furnace investigations. By using a current of 2,000 amperes at 80 volts, Moissan succeeded in obtaining a temperature of 3,500° C., and in volatilizing carbon. A temperature of 500° C. beyond that obtained in the electric furnace, therefore seems to indicate great possibilities for acetylene, as a source of heat in high temperature research.

On account of the detonating character of the explosions of mixtures of acetylene and air, it is unsafe to use a higher volume percentage of acetylene than 4 in gas engine experiments. M. Ravel lays stress upon the necessity for attention to the four points already noted when working with acetylene. Summarised these are:

a. Rapidity of flame propagation in explosive mixtures.
b. Low ignition temperature.
c. High combustion temperature.
d. High explosive force.

The experiments to decide its applicability to motor purposes were carried out in a double-acting 2-horse power gas engine. Comparative experiments with coal gas were made with the same engine. The best results were obtained with a consumption of 28.4 cubic feet of acetylene per hour, with an indicated horse power of 2 48; 85.3 cubic feet of coal gas per hour were requisite to obtain the same result. The ratio of the calories of heat generated by combustion in the calorimeter for acetylene and coal gas is about 2.5 : 1.

As a result of his experiments, M. Ravel comes to the conclusion that some special form of gas engine will be requisite in order to obtain safe working when acetylene is used.

Coming to the question of comparative expense, it is necessary to remark that the present sale price of calcium carbide, which varies from $80 to $140 per ton, is much in excess of its cost price. The latter, under the most favorable manufacturing conditions, is believed to be $30 per ton. Coal gas also is sold at a price much in excess of its real cost of production; and where it is manufactured for use on the spot, it is safe to take its cost as 20 cents per 1,000 cubic feet in place of 75 cents. Using these prices as a basis of comparison, we obtain the following figures for the cost of 1 indicated horse power hour, when using acetylene and coal gas.

The calcium carbide is estimated to yield 5 cubic feet of acetylene per pound. The costs of 1,000 cubic feet of acetylene, at the two prices $50 and $30 per ton for the carbide, are therefore $4.43 and $2.66 respectively.

	Cubic Feet Used per Indicated Horse Power Hour.	Cost. Per 1,000 Cubic Feet.	Per Indicated Horse Power Hr.
Coal gas.....	34.4	.75 cents.	2.48 cents.
		.20 "	.68 "
Acetylene.....	11.4	4.43 "	4.84 "
		5.16 "	2.90 "

Taking the higher estimates, we find that acetylene is nearly twice as costly as coal gas per indicated horse power hour when used in the present form of gas engine; and that if the "cost" prices of calcium carbide and coal gas be considered, the ratio rises to over 4 to 1.

Its use for motor purposes is consequently likely to be a very restricted one, and coal gas and oil would seem to be in little danger of displacement, the more so as the English Home Secretary has scheduled calcium carbide as an explosive, which means that it can only be stored and conveyed under special conditions, which are onerous. The fire insurance companies also forbid its use in buildings under their policies.

The manufacture of calcium carbide goes steadily forward, although its practical applications seem to be still in the experimental stage of development. Acetylene has been successfully tried on one of the French railways for lighting the carriages; but we have yet to learn that it has been permanently adopted for lighting purposes on any railway in this or other countries. There are estimated to be now 17 manufactories of calcium carbide in Europe and America. The majority of these are merely small experimental works, but some few of them are large undertakings; as, for example, the Pictet Company, in Brussels, with a capital of $400,000.

The famous Neuhausen Aluminum Company is arranging to commence the manufacture at Rheinfelden, near Bale. Another works for the same manufacture is being erected at the same spot by a German firm.

There is consequently likely to be fierce competition between the various producers of calcium carbide in the near future, and a fall in price similar to that witnessed in the aluminum industry in the years 1890–94 will most probably occur. Competition between the rival producers of aluminum caused a fall of 75 per cent. in price during the years named, and only two surviving companies remained at the end of this period of industrial competition. If such a fall is to occur in the calcium carbide industry, those companies laboring under excessive capital charges, or with heavy royalty charges to pay, will fare badly in the fight.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

THE Eastchester Gas Light Company, of Mount Vernon, N.Y., which is owned and operated by the American Gas Company, of Philadelphia, will erect a handsome office building fronting on Depot square, Mount Vernon. The structure is to be two stories over ground, and will be of brick with stone trimmings. When finished the building will be devoted entirely to the office, showroom and workshop needs of the Company. The contract for its construction has been awarded to Messrs. Jenks & Plume, and Superintendent Gerould will see to it that the work is properly done.

AT the annual meeting of the Canandaigua (N.Y.) Gas Light Company the following officers were elected: Directors, Messrs. Bradley Wynkoop, F. A. McKechnie, John D. McKechnie, Louis Sayer, J. E. Dayton and Mrs. H. L. Howe and Mrs. M. E. Sayer; President, Bradley Wynkoop; Secretary and Treasurer, F. A. McKechnie.

THE proprietors of the Hackensack (N. J.) Gas and Electric Company have at last turned their attention to increasing the use of gas for fuel in that locality. In a circular letter recently distributed freely throughout the place, they offer to connect up and install free of charge a small gas stove, provided the consumer will guarantee to use through it, in the course of a twelvemonth, gas amounting in value to $5.

THE Berlin Iron Bridge Company, of East Berlin, Conn., has been awarded a contract to furnish a steel roof for a large storehouse which is to be erected by the Waterbury (Conn.) Manufacturing Company. The building is to be 54 feet wide and 144 feet long, the side walls to be of brick and the roof to be supported by steel trusses. The covering is to be of corrugated iron lined with the Berlin Company's anti-condensation fireproof lining.

MR. JOEL EATON, who, in partnership with Mr. A. O. Swift, built the gas works at Council Bluffs, Iowa, in 1870, died at the Ogden House, Council Bluffs, on the evening of March 30th. He managed the Council Bluffs gas plant from the time of its completion until it passed into other hands some six or eight years ago. He was in his 53d year, and his earlier years were passed in Dedham, Mass. A brother and sister survive him.

ARTICLES incorporating the South Omaha (Neb.) Gas Company have been filed by Messrs. James Gilbert, B. E. Wilcox, Daniel Cameron, D. L. Holmes and M. D. Hyde. The capital stock is fixed at $150,000.

THE Standard Gas Company, of Whitewater, Wis., has been incorporated by Messrs. C. E. Gray, F. Borch and M. G. Jeffries. It is capitalized in $60,000.

MR. ANTHONY N. BRADY, President of the Municipal Gas Company, of Albany, N.Y., has informed the authorities that, on the 1st day of June next, the price of gas for illuminating purposes will be reduced to $1.50 per 1,000 cubic feet; the rate for fuel and power use to be $1.25. As heretofore, the City Building and the City Hall will be lighted free of charge.

WE understand that a similar course to the above has been determined on by the proprietors of the Troy (N.Y.) Gas Company.

AT a special meeting of the Directors of the Doylestown (Pa.) Gas Company Mr. Samuel Z. Freed was elected Secretary, vice Mr. Murfit. Mr. Freed is also Treasurer of the Company.

UNDER the agreement between Mayor Swift and Comptroller Wetherell, of Chicago, the Chicago Gas Companies have signed contracts to light the street gas lamps for the year ending December 31, 1897, at the rate of $20 per lamp. The Companies contracting to do the work (the Chicago Gas Light and Coke Company, the Peoples Gas Light and Coke Company, the Hyde Park Cas Company, the Suburban Gas Company and the Lake Gas Company) agree to pay into the city treasury the sum of 3½ per cent. on the gross receipts, the payments on such account to be made quarterly.

MR. WM. S. WATERBURY has sold to the Ballston Spa (N. Y.) Electric Light and Power Company all the rights and privileges heretofore enjoyed by him as proprietor of the Ballston Spa gas works.

"C. R. L.," writes from London, England, under date of March 27th: "On the eve of his departure for the United States, Mr. J. T. Westcott, chief representative of the Economical Gas Apparatus Construction Company, Limited, the headquarters of which Company are in Toronto, was entertained at the Whitehall Club by a few friends desirous of marking their appreciation of one who, since his arrival in this country some two years ago, has done so much to popularize the Merrifield-Westcott-Pearson carbureted water gas plant, to which he has devoted his time and talents. Laboring under adverse circumstances, it is not too much to say that Mr. Westcott has been singularly successful, for within this comparatively brief period he has fitted up machinery in divers parts of the kingdom capable of producing some 13,000,000 cubic feet of gas per day. He has been successful in making many friends in the English gas engineering world."

THE new gas rate ($2.25 per 1,000, from $2.50) for an illuminating use, at Webster, Mass., went into effect on the 1st inst. The rate for a fuel use ($1.75 per 1,000) remains unchanged.

THE City Council of Tiffin, O., has leased the municipal gas plant (formerly used to supply natural gas in that city) to Patrick Dowling, of Toledo, O., who agrees to furnish a manufactured fuel gas to the residents at the rate of 25 cents per 1,000 cubic feet. The agreement is to last for three years, and the rental is $4,200 per annum. We wonder how long Mr. Dowling will last at that rate.

THE Boston *Herald* says that the March output of the Boston Gas Companies fell off 5.04 per cent. from March of 1896, all Companies, with the exception of the Dorchester, showing a decrease. The comparative output of the Companies in the Bay State combination, for March, and for the first quarter of 1897, is given in the appended table:

Company.	March, 1897.	March, 1896.	Changes.
Boston.....	105,984,000	111,710,000	5,726,000 dec.
Roxbury.....	18,063,000	19,199,000	1,136,000 "
Dorchester.....	15,077,000	14,019,000	1,058,000 inc.
South Boston	9,402,000	9,574,000	172,000 dec.
Brookline.....	67,140,000	72,511,000	5,371,000 "
Total	215,666,000	227,013,000	11,347,000 dec.
For first quarter, 1897,	687,329,000	744,277,000	56,957,000 "

"OBSERVER" writes that Mr. A. S. K. Clark is acting as Treasurer of the Cambridge (Mass.) Gas Light Company, vice the late Mr. Adolph Vogl. He further says, it is not at all improbable that the Directors will formally name Mr. Clark as Mr. Vogl's successor.

THE new gas rate at Waltham, Mass., took effect April 1st. The gross rate has been reduced to $1.80 per 1,000, from $2, and prompt payment (within 15 days) entitles the consumer to a rebate of 10 per cent.

THE voters of Concord, Mass., have voted that it is expedient for the town to engage in the business of gas and electric lighting supply on public account.

THE Lawrence (Mass.) Gas Company has opened a branch office and showroom in the Methuen district.

THE Elgin (Ills.) American Gas Company has authorized Superintendent Dunbar to distribute 200 gas cooking stoves or ranges without making any charge therefor; the necessary condition being that the consumer shall deposit a sum of money equal the list price of the stove selected, which money shall be applied to in payment for the gas used until the deposit is exhausted. When the deposit is absorbed the stove becomes absolutely the property of the consumer.

THE Standard Oil Company is about to erect, at Bayonne, N.J., a boiler shop, 300 feet long and 105 feet wide. The main portion will be divided into three bays, the central bay (about 50 feet wide) to be served with a 15-ton electric crane, supported on heavy girders, about 40 feet above the floor. On either side of this main portion a wing is arranged for of about 30 feet in width. The walls of the building are to be of brick, the supporting frame is to be of steel, and the roofs are to be covered with corrugated iron. The main columns of the shop are to be 25 feet apart, and all are disposed so that jib cranes of suitable size and capacity can be attached at any point which, together with the traveling crane in the center, will enable them to cover the entire floor surface of the building. One end of the building, for a distance about 75 feet in length, is supported by clear span trusses, which gives a clear floor space over the entire area. In this end of the building will be located furnaces, fires and other apparatus for heating and shaping the material for the boilers. The building will be well lighted by windows in the side walls, and in the monitors of the roof, and will be amply ventilated by means of large monitors on the ridge. The steel work for the structure was designed and will be erected by the Berlin Iron Bridge Company, of East Berlin, Conn.

THE betterments on the gas and electric light plants of the New London (Conn.) Gas and Electric Company are being carried out under the supervision of Mr. E. A. Blackwell, the Company's Chief Engineer.

MISS LUCY C. ANDREWS has been engaged by the Kansas City-Missouri Gas Company to give several demonstration lectures on cooking by gas in that city. The lectures will be given at stated times during the months of April and May, at various points in the city.

A CORRESPONDENT forwards the following: "The annual meeting of the shareholders of the Knoxville (Tenn.) Gas Company was held on the 2d inst. From the annual reports it was learned that the Company had expended $4,000 last year in main extensions, and that $1,200 had been invested in new meters. Out of the 3,360 shares in the Company, 2,637 were voted on at the meeting. This year a determined effort will be made to induce the householders to go in for cooking by gas. The officers chosen were: Directors, J. L. Rhea, E. H. Saunders, J. E. Hood, A. D. Leach, R. R. Swepson, J. Y. Johnston and W. P. Washburn; President, R. R. Swepson; Vice President, A. D. Leach; Secretary and Treasurer, E. H. Saunders.

MR. GEORGE LA FAYETTE MORRIS, formerly prominent in the affairs of the Birmingham (Ala.) Gas Company, died at his home in that city on the evening of March 29th. He was in his 48th year, having been born in Spring Place, Ga., in 1849.

THE Special Committee of the Philadelphia Common Council, appointed to investigate the supply and distribution of the gas purchased by the city under contract with the Philadelphia Gas Improvement Company, has presented its report, which is quite favorable to the contractors. In summing up, the Committee said: "Your Committee, being appointed to investigate the supply and distribution of the water gas, could not extend its inquiry into the supply and distribution of coal gas, except as it affected the water gas. The analysis furnished the Committee by the Drexel Institute forces us to believe that in the manufacture of coal gas there must be something radically wrong, or there would not be such a large percentage of nitrogen, which is almost as destructive to the candle power of the gases as carbonic acid. That the mains generally are in bad condition is a matter of record, and the testimony of Chief Park in this respect is simply a reiteration of a fact that is already known to Councils, and there is no doubt in the mind of your Committee that the city suffers a great loss and the consumers have cause for complaint from their imperfect condition. Your Committee would therefore recommend and suggest that Councils take such action that will enable the city to test the quality and value of the water gas purchased by supplying one district exclusively with it. This can be readily done; it will entail some expense, but the question of the gas supply to the city of Philadelphia is one of great importance, and the expense would be justified by the value of the information that would be gained. In determining what is the best supply for the rapidly increasing demand for gas, it can be readily seen this method of distribution would enable us to not only test the quality of the water gas at the points of consumption, the loss by condensation and leakage in comparison with coal or mixed gas, but also the profit accruing from its exclusive sale. Your Committee would further recommend that Councils give their immediate attention to the perfecting of the distribution system of the city by the introduction of new mains, which will provide for adequate pressure, by which the present evils resulting from insufficient pressure will be done away with. We also recommend that analysis be made at regular intervals of the gas manufactured at the different works of the city, and also from different sections of the city where it is distributed."

JUDGE BRUBAKER has decided that the consolidation of the Lancaster (Pa.) Gas Light and Fuel Company with the local electric lighting

companies was performed and accomplished quite within the stipulations of the law.

THE capital stock of the Queen City Gas Company, of Buffalo, N.Y., has been increased to $1,000,000. It is also said that the Company has purchased a plot of 6½ acres fronting on Scajaquada creek, wherein it is proposed to erect a water gas plant up to a daily output of 3,000,000 cubic feet.

The Improved Fleuss Breathing Apparatus for Mine Exploration.

In a paper by Mr. George H. Winstanley, before the Manchester (England) Geological Society, the author, in commenting on the matter named in the heading, said:

Every review of the history of coal mining brings before us the numerous and great advances which have been made in connection with colliery operations during the past hundred years. Improvements calculated to reduce the expense of working, improvements intended to secure the safety of those engaged, have been carefully planned out, and to a very great extent successfully adopted; but there is one direction, at least, in which little or no advance seems to have been made —viz., facilities for rescuing those whose lives are endangered when, in spite of all precautions, an accident has happened. This, of course, refers more especially to explosions of gas or coal dust, which, although much less frequent than formerly, still is to be regretted, have from time to time to be recorded.

A colliery may be provided with high class ventilating machinery; the workings may be ventilated most systematically and scientifically; safety lamps of the most improved type may be adopted; carefully selected explosives, used in connection with the safest system of firing, may be employed; and still in spite of all these precautions we know only too well that that an explosion is by no means impossible. The improvements, however, seem to go no further, and, in the event of such a disaster, it would seem as if the facilities for rescue work were no greater than in the days of George Stephenson.

To understand the use and application of the Fleuss apparatus, the following explanation given by the writer of the paper is sufficiently expressive without further supplementary description on our part.

To follow the action of the Fleuss apparatus it will be necessary for a moment to consider briefly the operations of ordinary respiration. The necessary element in the atmosphere to support life is oxygen; this gas is mixed with nitrogen, the latter merely acting as a dilutant, and in no way entering into the actual process of respiration. The air which is drawn into the lungs is enabled to act upon the blood and a process of combustion goes on, the oxygen combines with some of the carbon in the blood to form carbon dioxide, and this, together with the nitrogen, is exhaled into the atmosphere. It will thus be seen that if a person were placed in a sealed chamber, he would by his breathing gradually use up all the oxygen, and at the same time charge the atmosphere with a gradually increasing percentage of carbon dioxide. This would go on until the person became insensible and finally expired.

In order to permit healthy respiration, therefore, two things are essential. First, there must be some means of maintaining a supply of oxygen, and secondly, some means of removing the excess of carbon dioxide. How these are accomplished in nature it is not our present purpose to inquire; in the Fleuss apparatus the necessary conditions are brought about in the manner now to be described.

The original apparatus consisted of a mask to cover the face, a copper cylinder containing a supply of oxygen gas under pressure, a rubber bag worn in front and called the breathing bag, and the carbonic acid gas filter, together, of course, with the necessary tubes connecting the different parts and the straps for the purpose of carrying.

The arrangement referred to above as the carbonic acid filter, in the original apparatus took the form of a rectangular box strapped to the back like a soldier's knapsack. Internally the box was divided into vertical compartments, each filled with tow impregnated with caustic soda. Up and down these compartments the exhaled breath was made to pass, and in this way was freed from its carbon dioxide. Caustic soda has the property of actively combining with this gas forming carbonate of soda.

This arrangement was most unwieldy, in fact, quite useless in any but a mine where the roads were uniformly high, and where no small places had to be passed through. In the present form of the appliance, however, this cumbersome arrangement has been dispensed with entirely, and the caustic soda, in the form of sticks, is placed in the breathing bag.

This is made in two forms, one simply covers the nose and mouth, and would be generally used in mining work; the other also covers the eyes, and would be used in smoke or fumes injurious to the eyes. In both cases the mask fits closely to the face, and is provided with two corrugated rubber tubes, one being the tube for inspiration and the other for the exhaled breath. Each tube is provided with an exceedingly simple valve which responds to the very feeblest efforts of breathing.

The mask is connected with the breathing bag by means of the corrugated tubes referred to above, the bag is of good rubber, and is worn in front, occupying very little space. Internally the bag is divided into two compartments, into each of which a quantity of stick caustic soda is placed (2 pounds) when the apparatus is to be used.

It is in connection with this portion of the appliance that the writer has attempted to make further improvements, by reducing the weight and bulk of the apparatus as well as increasing its utility as a life-saving appliance. The oxygen cylinder supplied with the set of apparatus by Messrs. Siebe, Gorman & Company, the eminent firm of submarine engineers, who are the sole makers of the apparatus, is made of copper. The writer believes that copper was chosen in the first instance because, when the apparatus was first brought out, steel cylinders for compressed gases were unknown. Copper also is the favorite metal of submarine engineers, being able to withstand the corrosive action of sea water so much better than steel, and possibly this may to some extent explain why copper is still used. The copper cylinder exhibited measures 6 inches in diameter and 15 inches long over all; charged with gas and including the carrying straps, its weight is over 20 pounds, and at a pressure of about 400 pounds to the square inch it contains oxygen equal to about 4 cubic feet, a quantity sufficient to last for three or four hours' breathing.

The total weight of the apparatus with the copper cylinder all ready for use is 30 pounds, and the cost is about $65 per complete set.

To use the apparatus the cylinder is first strapped to the back by means of the belt and shoulder straps, next the bag is placed in position in front, it already having been charged with 4 pounds of caustic soda.

The small rubber tube from the valve of the oxygen cylinder is connected with the corrugated inspiration tube, both the corrugated tubes are connected to the mask and to the bag, and the mask slung round the neck in readiness to be adjusted. The person then enters the mine and advances until the atmosphere shows signs of being impure, when he adjusts the mask, at the same time turning the oxygen valve to admit oxygen to the bag; this valve is closed again so soon as the bag is sufficiently distended. Breathing then proceeds naturally, the air is drawn into the lungs, the oxygen converted into carbonic acid, which is exhaled into the bag together with the unaltered nitrogen. The carbonic acid coming in contact with the caustic soda is absorbed by it, and in this way the breathing continues until the bag begins to show signs of getting "flabby" from loss of oxygen; more of the latter is then admitted, this being necessary about once every 10 minutes. The oxygen is not admitted in a continuous stream, but intermittently, the idea being to keep the bag distended between a certain minimum and maximum, when the proportion of oxygen present will be such as to properly sustain breathing. It perhaps ought to be remarked at this point that the atmosphere which the person breathes consists of oxygen and nitrogen, in which the former is always slightly in excess of the proportion which is present in the normal atmosphere, and its proportion is not constant, but varies. When first oxygen is admitted, and the bag distended to the maximum extent, the percentage of oxygen breathed is above that in the normal atmosphere, and this gradually diminishes until the proportion is just above normal, when more oxygen is admitted. The breathing of this slightly excess quantity of oxygen is not harmful or dangerous.

The Jacques Carbon Generator.

The Journal of the Franklin Institute notes that since the publication of the experiments of Dr. Jacques with an apparatus for generating energy directly from coal, the technical journals have devoted much space to the discussion of the merits of his work. The strongest adverse criticisms that have been made in relation thereto have originated with Mr. C. J. Reed, who has challenged the correctness of the author's explanations as to the origin of the energy developed in the Jacques apparatus, and who has, we think, successfully demonstrated that the

(*Continued on page 571.*)

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(*Continued from page* 570.)

phenomena observed are thermo electric (deriving their source from the fuel consumed in maintaining the apparatus in action), and not electrolytic.

In a recent article published in *Harper's* Dr. Jacques makes an interesting exposition of the subject from his standpoint. He announces certain convictions, of which we give an abstract in what follows:

The first is that the electric current was due to the chemical combination of the oxygen of the air with the coke (carbon). Quantitative tests showed that oxygen was taken from the air; that the carbon was consumed; that carbonic acid was formed. At the same time the electromotive force obtained agreed almost exactly with that theoretically obtainable from the combination of oxygen and carbon to form carbonic acid (1.04 volts). That the phenomenon was not due to the thermo-electric action was proved by the fact that when the whole apparatus was so inclosed that all parts were kept of uniform temperature the maximum electromotive force and current were obtained Some experiments with larger apparatus have confirmed these results, and have shown that under proper conditions the electrical energy obtainable from one of these generators is substantially equal to the potential energy of the weight of carbon consumed within the pot.

So far, only relatively small carbon electric generators have been built, and the author points out that with this generator, as with the steam engine, increased size means increased efficiency per pound of coal. Some results of a test (made by experts not connected with the development of the invention) upon a small and comparatively crude 2-horse power carbon electric generator that has been in occasional use for some six months, are as follows: Average electrical horse power developed, 2.16 horse power; average electrical horse power used by air pump, 0.11-horse power; average net electrical horse power developed, 2.05-horse power; carbon consumed in pots per electrical horse power hour was 0 223 pound; coal consumed on grate per electrical horse power hour was 0.336 pound; total fuel consumed per electrical horse power hour, 0.559 pound. The electricity obtained from 1 pound of coal (of which 0.4 pound was consumed in the pots and 0.6 pound was burned on the grate) was 1,339 watt hours, or 32 per cent. of that theoretically obtainable.

These figures, it is claimed, show that the efficiency of this particular generator was 12 times greater than that of the average electric light and power plant in use in this country, and 40 times greater than plants of corresponding size. There are, the author says, many details still to be worked out, and many improvements yet to be made, before the carbon electric generator can be put into general commercial use on a scale comparable with that of modern steam engines.

The Market for Gas Securities.

The market for city gas shares last week was active, and the trading in all the Companies' shares was done at very much higher figures than those reported for some time back. A record was made in New York and East River common, which is said to have sold at 57, and our quotation for it to-day is 56 to 57. The preferred, too, sold up to 93, and it is said by those in the know that the stock is close to appearing regularly on the dividend paying list. Mutual is 240 bid, Equitable is 208 bid, and Standards are steady and strong. Consolidated sold up to 161¼, and opened to day (Friday) at 161 to 162. The passage by the Senate of the bill to grade the rate in New York for 5 years on a 5 cent. yearly reduction, and by so decided a vote, accounts no doubt for the courage shown by investors in taking up city gas shares at the advancing figures. While there is little doubt that the bill will pass the Assembly, investors should remember that Mayor Strong will be called on to either approve or disapprove the measure, and our idea is that he will veto it. It all then depends on whether or not there will be sufficient time between such possible rejection and the adjournment of the Legislature to re-enact it. There will, however, likely be time enough to re-pass it, and in our belief city gas shares are cheap at present figures, right on their merits.

Brooklyn-Union gas scored an advance of 10 points for the week, the opening to-day having been made at 106 to 107. The bonds are 111 bid. Chicago gas sold up to 81¼ this morning, and is likely to go higher. Consumers gas, of Jersey City, has advanced to 75 bid, and the bonds are 101 to 103. Bay State gas is 9⅜ to 9½, and it is very cheap at those figures. Columbus (O.) gas moved up quite sharply, and it is quite in the possibilities that much higher figures over it will be made before long. Our output figures, which have almost uniformly shown losses for February and March, 1897, as against February and March, 1896, are beginning to show a return to normal conditions. The first five days of April, against the first five days of the same month a year ago, showing a gain for the former. The returns referred to cover 12 points that can safely be taken to indicate fairly the general state of trade.

Gas Stocks.

Quotations by Cochran & Close, Brokers and Dealers in Gas Stocks,
35 WALL ST., NEW YORK CITY.
APRIL 12.

☞ All communications will receive particular attention.
☞ The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$35,430,000	100	161	162
Central	500,000	50	195	..
" Scrip	220,000	..	100	.
Equitable	4,000,000	100	208	210
Bonds, 6's	1,000,000	1,000	105	..
" 1st Con. 5's	2,300,000	1,000	114	.
Metropolitan Bonds	658,000	..	108	112
Mutual	3,500,000	100	240	..
" Bonds	1,500,000	1,000	100	102
Municipal Bonds	750,000	.	..	.
Northern	150,000	50	85	
" Bonds	150,000	1,000	..	98
New York and East River	5,000,000	100	56	57
Preferred	2,000,000	100	92½	93
Bonds 1st 5's	3,500,000	1,000	107	107½
" 1st Con. 5's	1,500,000	..	100	100½
Richmond Co., S. I.	348,650	50	50	..
" Bonds	100,000	1,000	..	.
Standard	5,000,000	100	88	90
Preferred	5,000,000	100	111	113
Bonds, 1st Mortgage, 5's	1,500,000	1,000	111½	113½
Yonkers	299,650	50	130	
Out-of-Town Companies.				
Brooklyn Union	15,000,000	100	106½	107
" " Bonds (5's)	15 000,000	1,000	111	..
Bay State	15,000,000	50	9⅜	9½
" Income Bonds	2,000,000	1,000	..	35
Boston United Gas Co.—				
1s Series S. F. Trust	7,000,000	1,000	..	85
2d " " "	3,000,000	1,000	70	72
Buffalo Mutual	750,000	100	125	..
" Bonds	200,000	1,000	95	100
Central, San Francisco	2,000,000	..	95	..
Chicago Gas Co.	25,000,000	100	81⅜	82
Chicago Gas Lt. & Coke Co. Guaranteed Gold Bonds.	7,650,000	1,000	94	94¼
Columbus	1,069,000	..	72	74
1st Mortgage	1,065,000	..	..	96
Consumers, Jersey City	2,000,000	100	75	80
" Bonds	600,000	1,000	101	103
Cincinnati G. & C. Co.	8,500,000	100	202	203
Consumers, Toronto	1,600,000	50	184½	187
Capital, Sacramento	500,000	50	..	35
Bonds (6's)	150,000	1,000	..	..
Consolidated, Baltimore	1,000,000	100	59¾	60
Mortgage, 6's	3,600,000	..	107	107½
Chesapeake, 1st 6's	1,000,000	..	..	..
Equitable, 1st 6's	910,000	..	..	..
Consolidated, 1st 5's	1,490,000	..	..	..
Detroit	4,000,000	..	22	..
" Con. Bonds	4,312,000	..	72½	74
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1,000	..	101
Fort Wayne	2,000,000	..	81	88
" Bonds	2,000,000	..	92	93½
Hartford	750,000	25	..	145
Indianapolis	2,000,000	..	130	135
" Bonds, 6's	2,650,000	..	105½	107½
Jersey City	750,000	20	180	..
Lafayette Gas Co., Ind.	1,000,000	100	84	87
Bonds	1,000,000	1,000	92	95
Louisville	2,570,000	50	..	..
Laclede, St. Louis	7,500,000	100	22	23
Preferred	2,500,000	100	73	78
Bonds	9,084,400	1,000	95¼	96¼
Little Falls, N. Y.	50,000	100	..	100
Bonds	25,000	..	..	100
Montreal, Canada	2,000,000	100	200	.
Newark, N. J., Gas Co.	1,000,000	..	93	98
Bonds, 6's	4,000,000	..	123	..
New Haven	1,000,000	25	225	..
Oakland, Cal.	2,000,000	..	53½	54
" Bonds	750,000	..	..	..
Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage	20,100,00	1,000	..	108
2d "	2,500,000	1,000	104	105
Peoples, Jersey City	500,000	50	..	175
Rochester Gas & Elec. Co.	2,150,000	50	..	..
Preferred	2,150,000	50	88	..
Consolidated 5's	2,000,000	..	87½	90
San Francisco, Cal.	10.000,000	100	97¾	98¼
St. Paul Gas Light Co.	1,500,000	100	79	81
1st Mortgage, 6's	650,000	..	84	87
Extension, 6's	600,000	..	..	..
General Mortgage, 5's	2,400,000	.	88	90
Syracuse, N. Y.	500,000	25	..	..
Washington, D. C.	2,000,000	20	250	.
Western, Milwaukee	4,000,000	100	64	65
Bonds, 5's	3,556,000	.	93½	95½
Wilmington, Del.	500,000	50	180	182

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DIVIDEND NOTICE.

OFFICE OF THE UNITED GAS IMPROVEMENT CO., DREXEL BUILDING, PHILA., March 25, 1897.

The Directors have this day declared a quarterly dividend of 2 per cent. ($1 per share), payable on April 15, 1897, to stockholders of record at the close of business March 31. Checks will be mailed.

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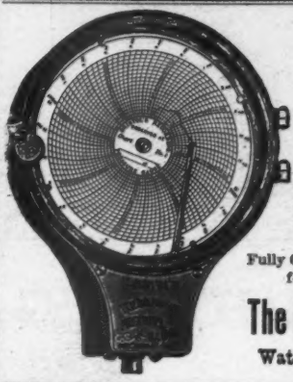

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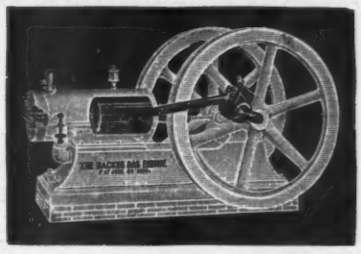

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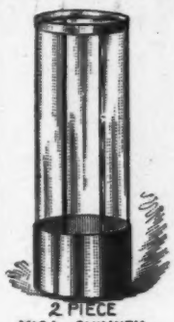

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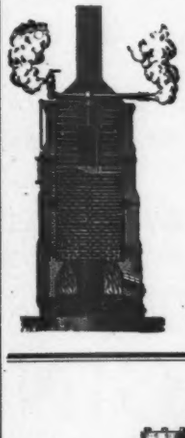

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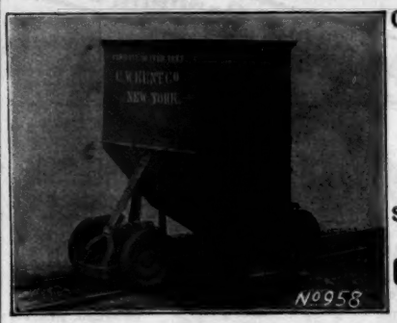

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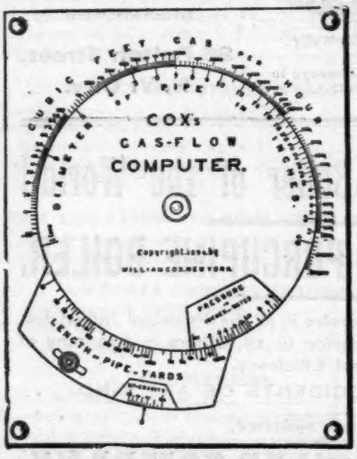

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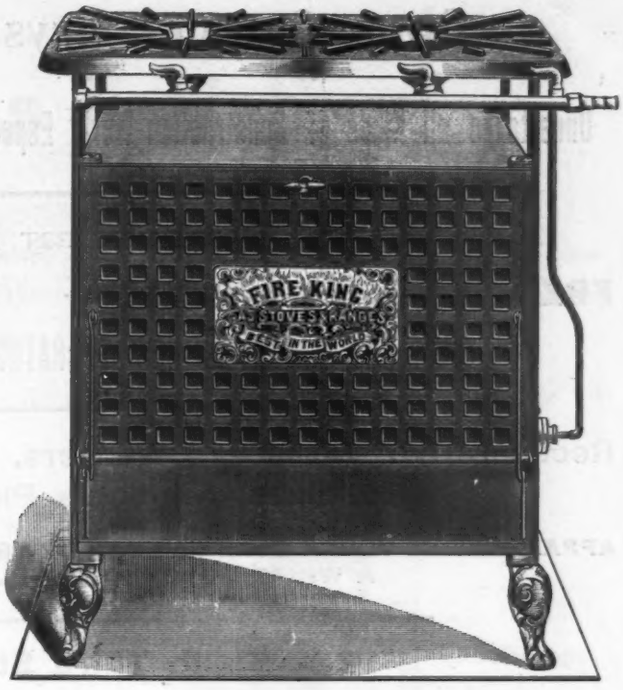

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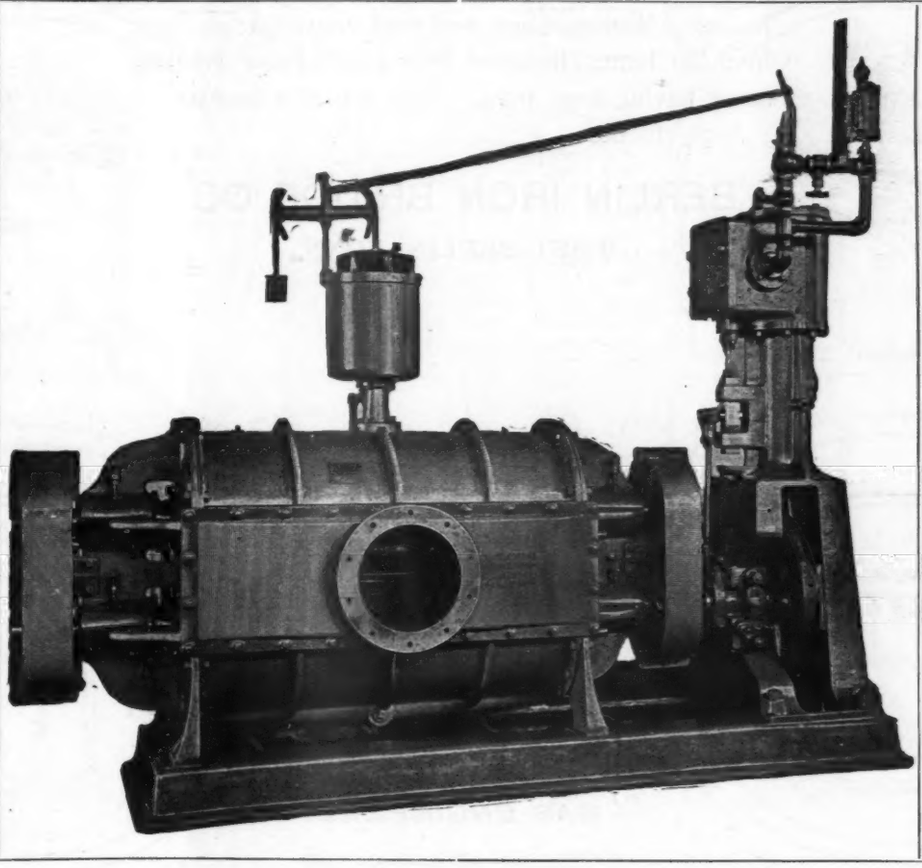

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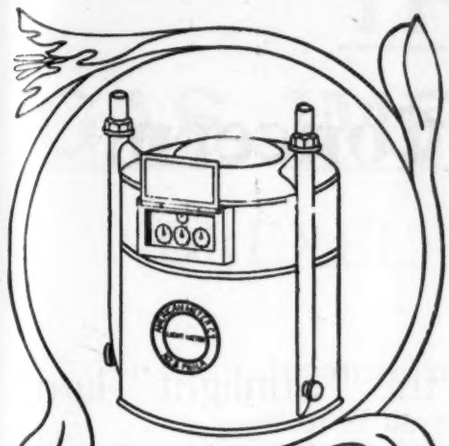

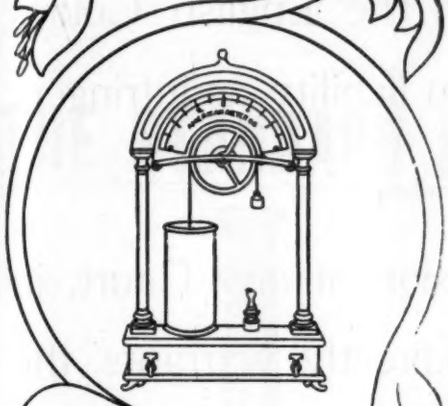

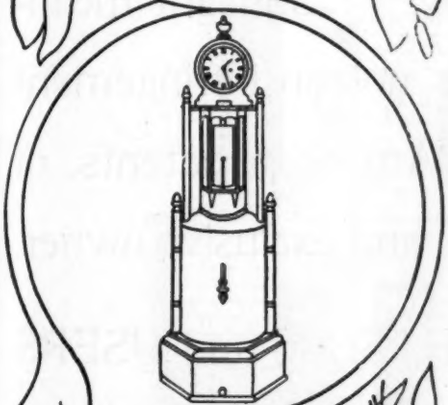

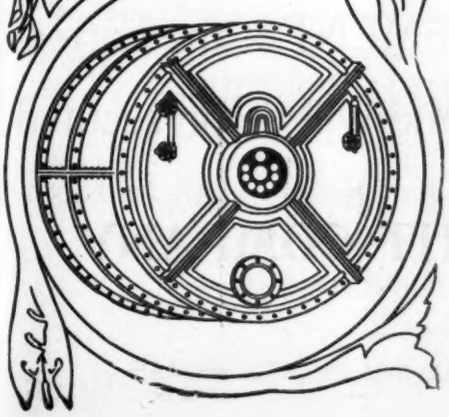

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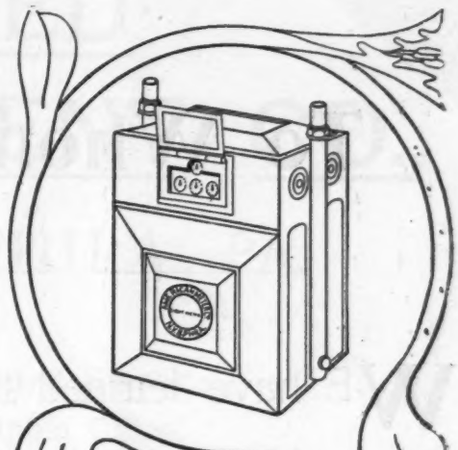
PUBLIC LIGHTING TABLE.

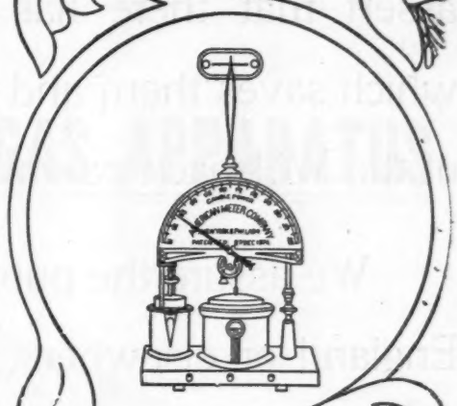
APRIL, 1897.

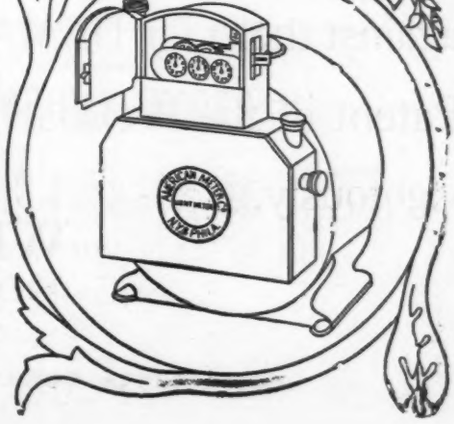
Day of Week.	Date.	Table No. 1. Following the Moon. Light.	Table No. 1. Following the Moon. Extinguish.	Table No. 2. New York City. All Night Lighting. Light.	Table No. 2. New York City. All Night Lighting. Extinguish.
				P.M.	A.M.
Thu.	1	6.50 FM NM	4.50 AM	6.10	4.55
Fri.	2	6.50	4.50	6.15	4.40
Sat.	3	6.50	4.50	6.15	4.40
Sun.	4	7.00	4.30	6.15	4.40
Mon.	5	7.00	4.30	6.15	4.40
Tue.	6	10.20	4.30	6.15	4.40
Wed.	7	11.10	4.30	6.15	4.40
Thu.	8	12.00 AM	4.30	6.15	4.40
Fri.	9	12.40 FQ	4.30	6.25	4.30
Sat.	10	1.20	4.30	6.25	4.30
Sun.	11	1.50	4.20	6.25	4.30
Mon.	12	2.10	4.20	6.25	4.30
Tue.	13	2.40	4.20	6.25	4.30
Wed.	14	3.10	4.20	6.25	4.30
Thu.	15	No L.	No L.	6.25	4.30
Fri.	16	No L. FM	No L.	6.30	4.20
Sat.	17	No L.	No L.	6.30	4.20
Sun.	18	7.20 PM	10.00 PM	6.30	4.20
Mon.	19	7.20	11.20	6.30	4.20
Tue.	20	7.20	12.30 AM	6.30	4.20
Wed.	21	7.20	1.20	6.30	4.20
Thu.	22	7.20	2.10	6.30	4.20
Fri.	23	7.20 LQ	2.40	6.40	4.10
Sat.	24	7.20	3.10	6.40	4.10
Sun.	25	7.20	3.30	6.40	4.10
Mon.	26	7.20	3.50	6.40	4.10
Tue.	27	7.20	4.00	6.40	4.10
Wed.	28	7.20	4.00	6.40	4.10
Thu.	29	7.20	4.00	6.40	4.10
Fri.	30	7.20	4.00	6.45	4.00

TOTAL HOURS LIGHTING DURING 1897.

By Table No. 1.	Hrs. Min.	By Table No. 2.	Hrs. Min.
January	233.00	January	423.20
February	187.20	February	355.25
March	202.00	March	355.35
April	170.40	April	298.50
May	163.00	May	264.50
June	140.40	June	234.25
July	151.40	July	243.45
August	167.30	August	280.25
September	174.40	September	321.15
October	200.00	October	374.30
November	205.20	November	401.40
December	220.10	December	433.45
Total, yr.	2216.00	Total, yr.	3987.45







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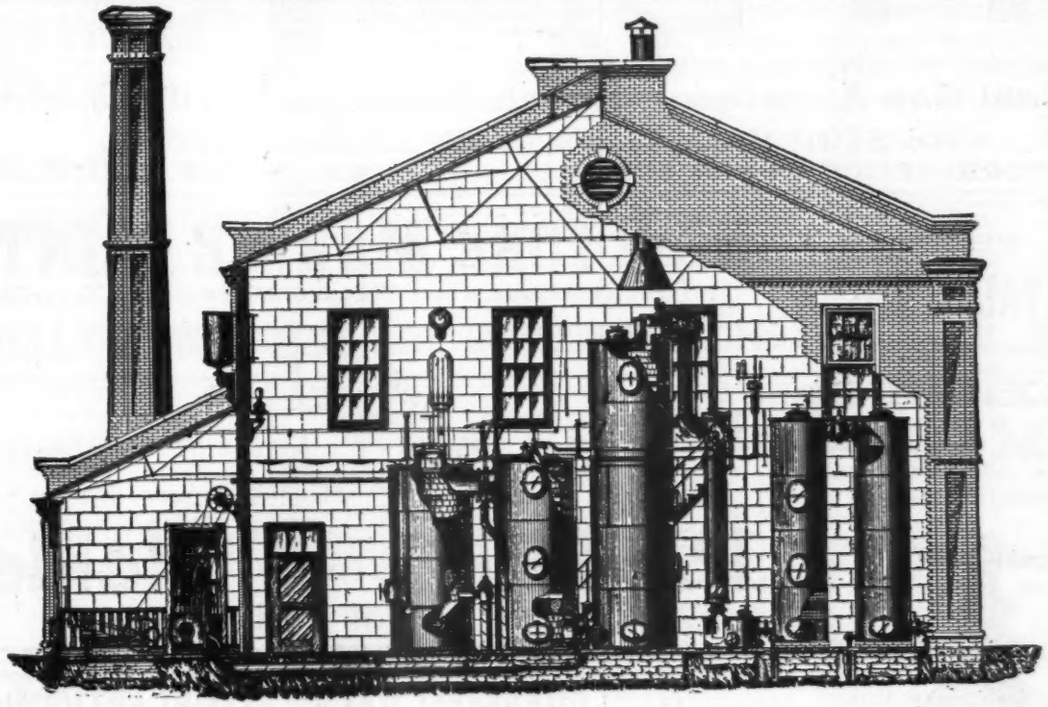

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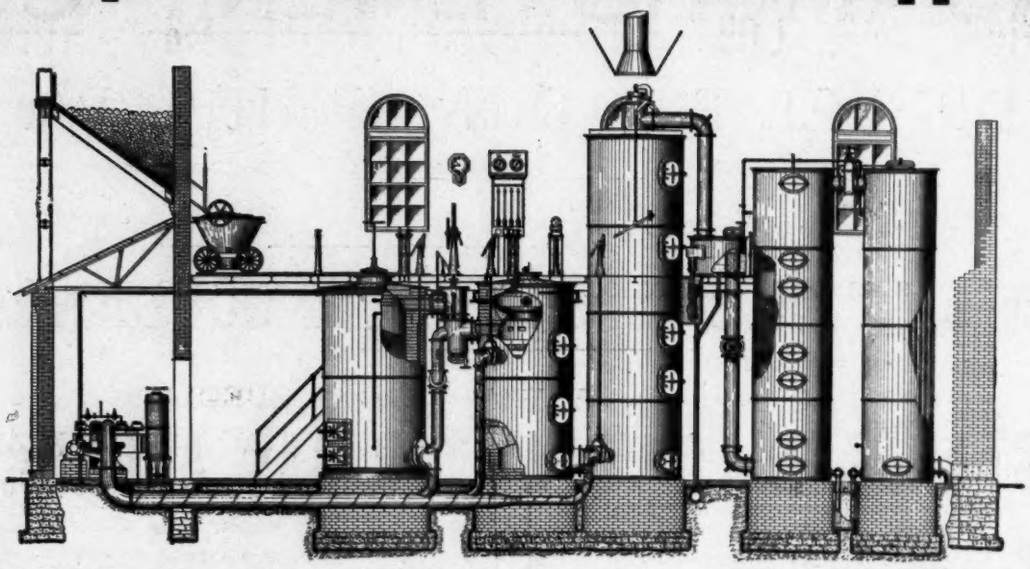

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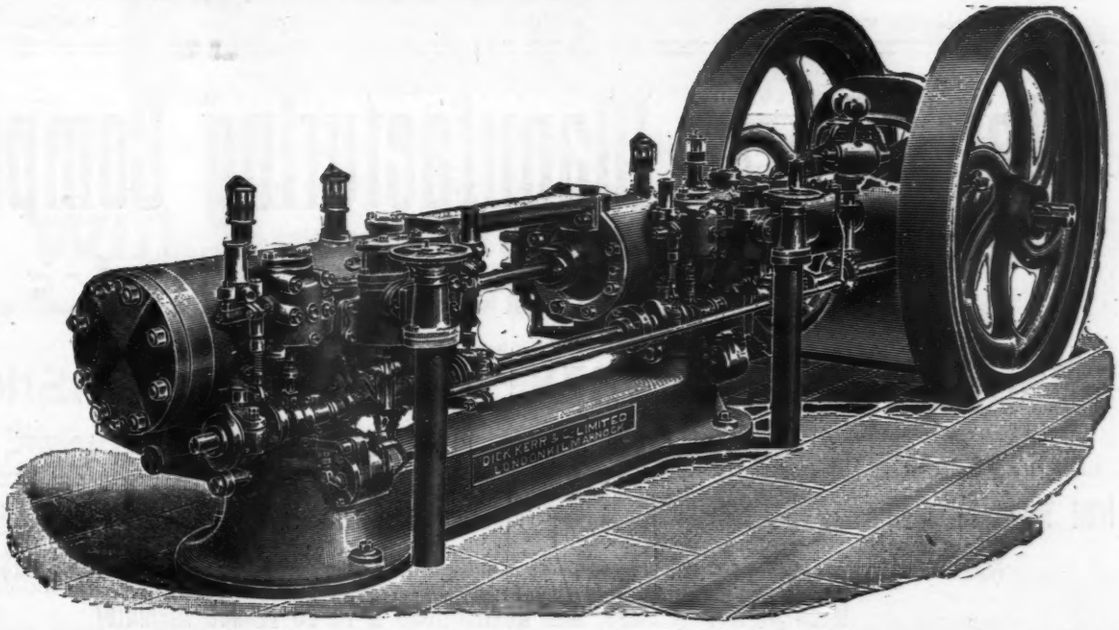

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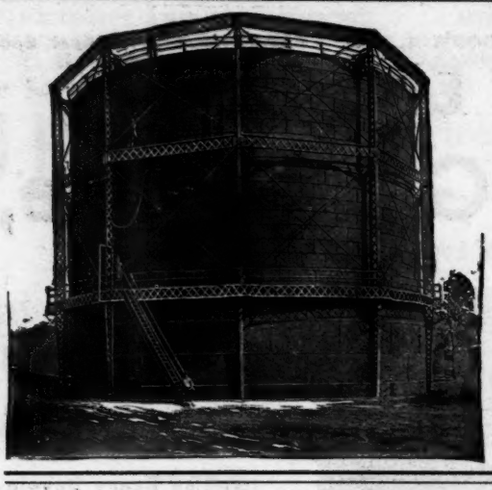

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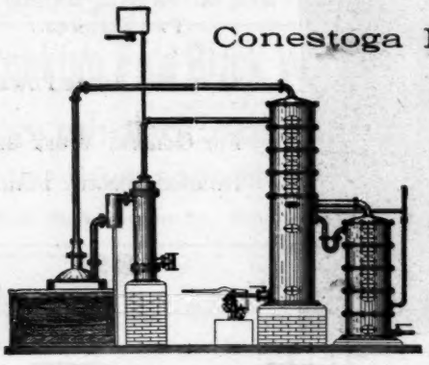

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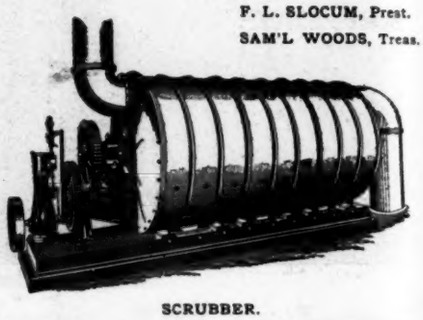

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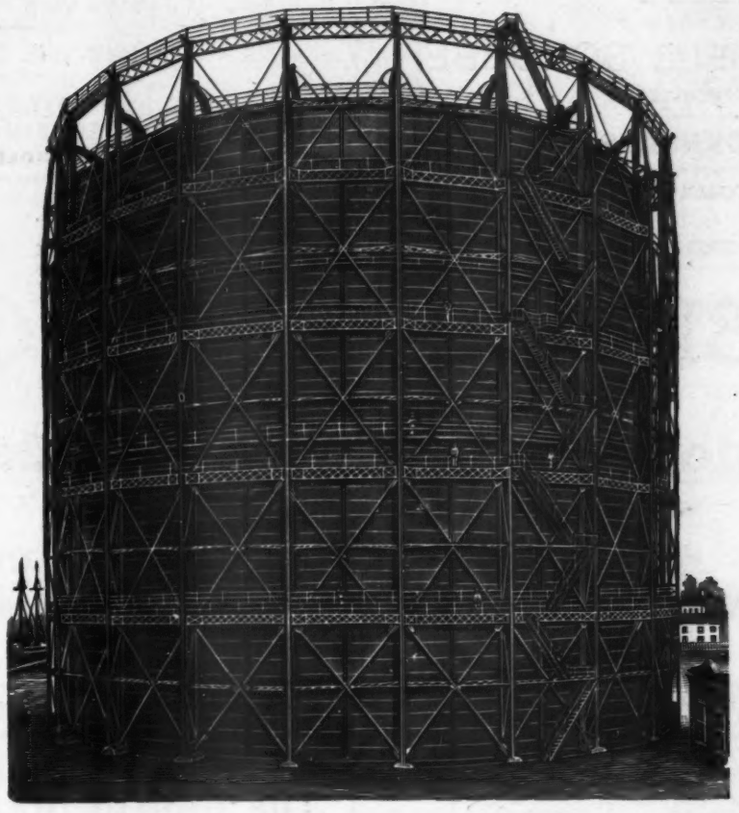

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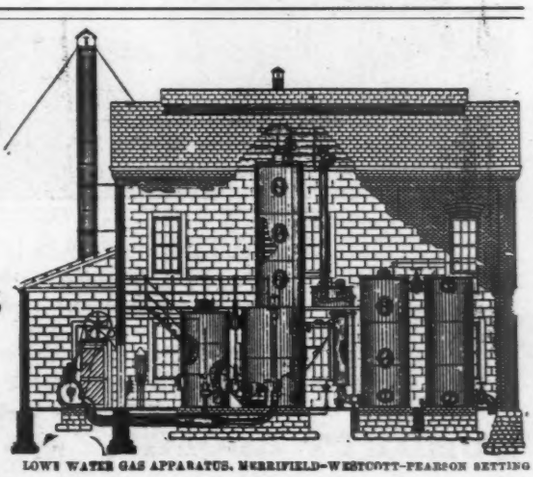

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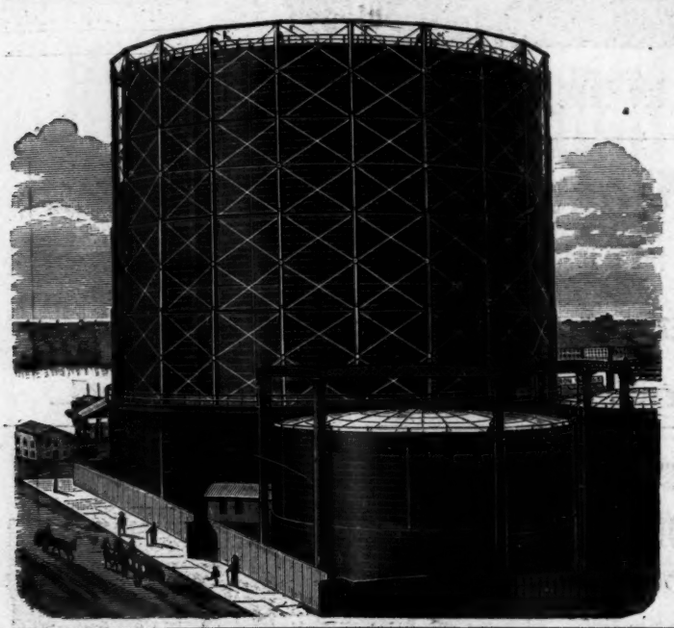

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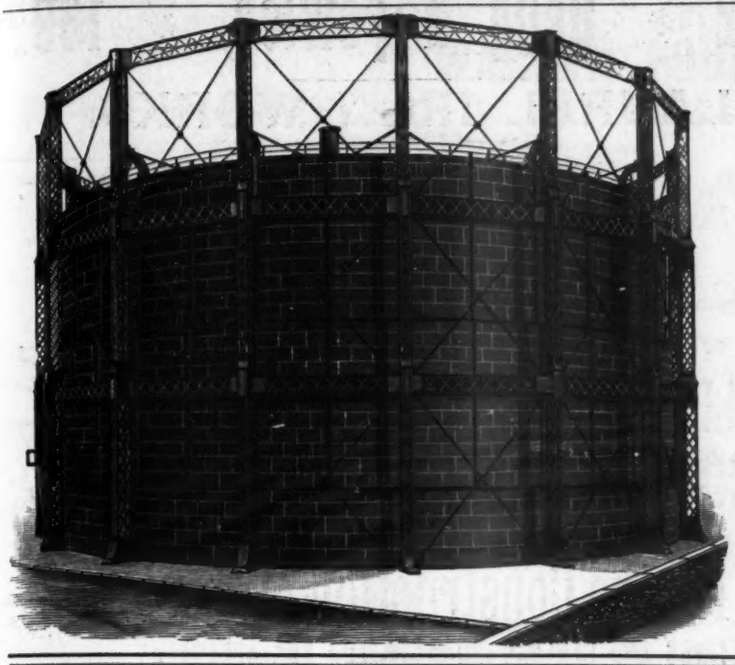

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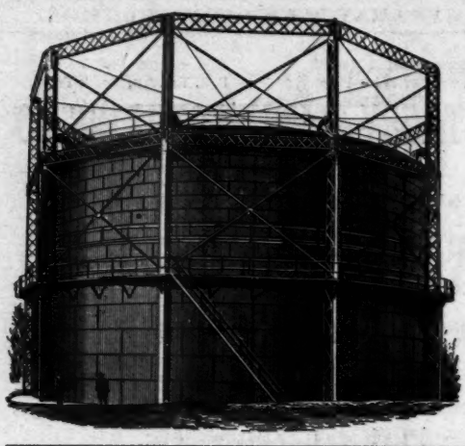

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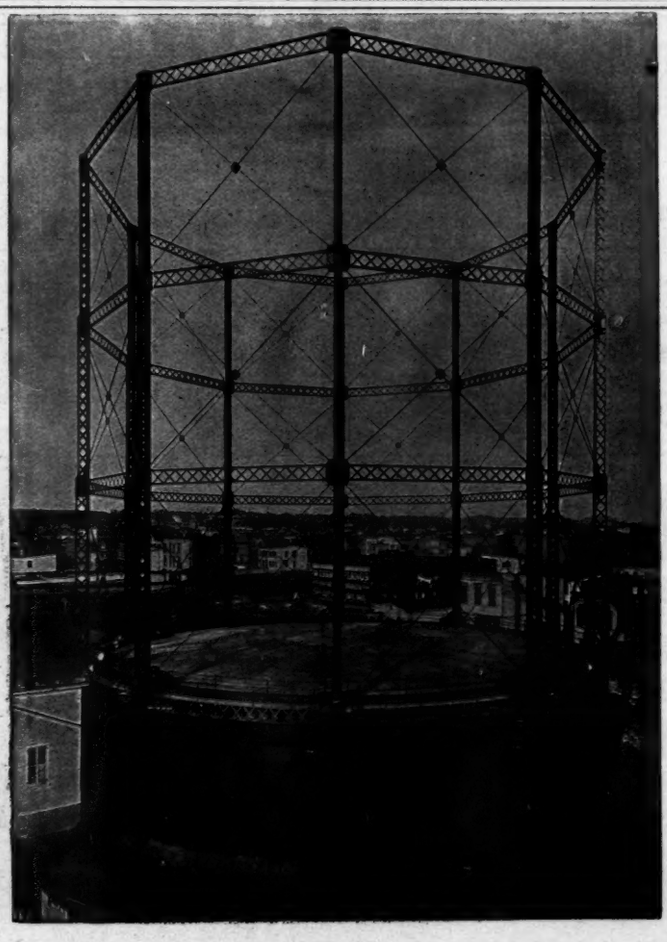

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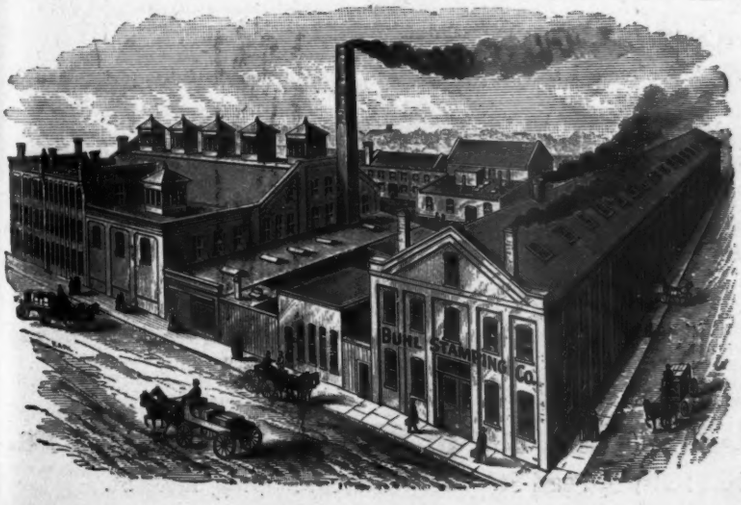

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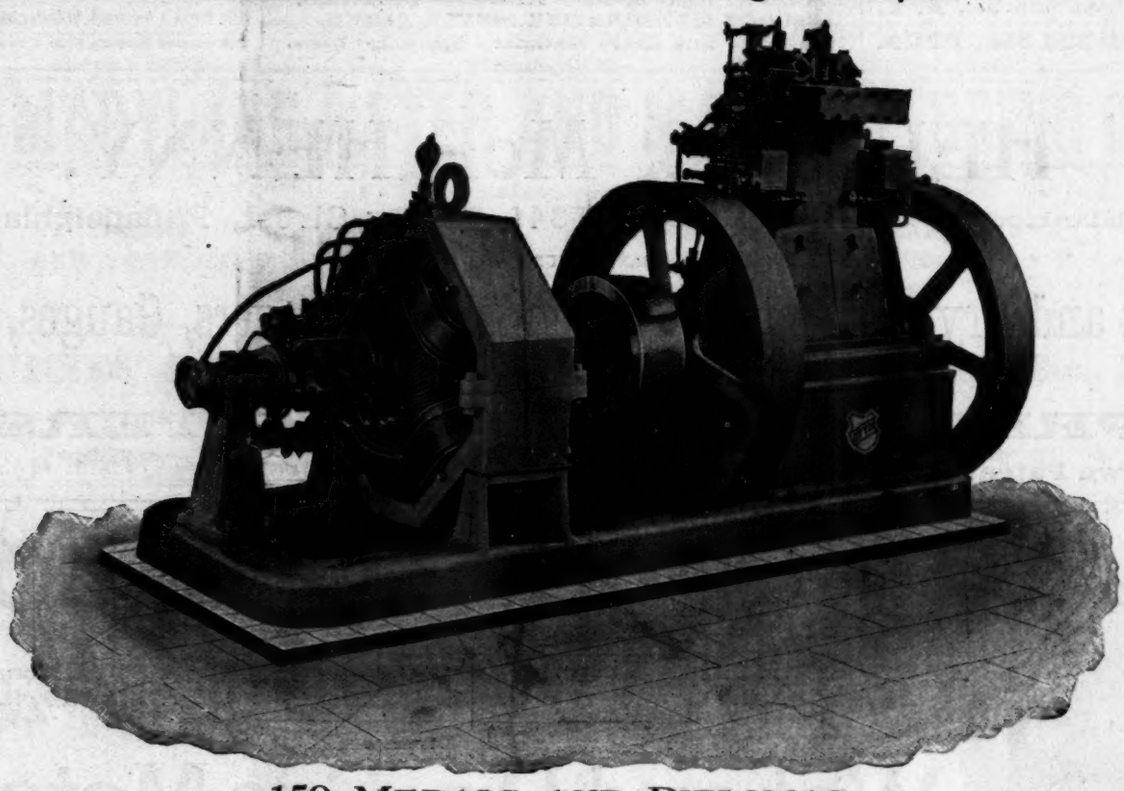

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